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New York University
Constant Level Balloons
Section 3, *Summary of Flights*
July 15, 1949

Technical Report No. 93.02

CONSTANT LEVEL BALLOONS
Section 3

SUMMARY OF FLIGHTS

Constant Level Balloon Project
New York University

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Prepared by: James R. Smith

James R. Smith

Approved by: Harold K Work

Dr. Harold K. Work
Director of the Research Division

College of Engineering
New York University
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New York 53, New York

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Introduction

In November, 1946 the Research Division of the College of Engineering of New York University contracted with Watson Laboratories, AMC, to develop and fly constant-level instrument-carrying balloons. This is the third part of the final report on the work accomplished and describes the experimental balloon flights which were made.

In reviewing the flights a number of analytical comments may be made. In most flights one objective was the maintenance of the balloon at a constant pressure level for as long as possible. On many flights balloon behavior was affected by instrumental controls of one kind or another while on some flights no controls at all were used.

Balloons of varying sizes and of different principles of construction have been launched singly, in tandem and in clusters. On some, temperatures were measured and on others the flight path was an object of special study. To explain certain observed flight data a careful analysis of atmospheric stability has been made, while other flights have special significance because they demonstrate the effect of superheat on the lifting gas or some other feature of analytical importance.

Since over 100 flights have been made, it is difficult to tabulate the important results obtained on each specific flight. To present the data which has been collected each significant flight is presented chronologically, with drawings and details where necessary, and a summary of the flight results is given.

To render this information useful, an index has been prepared with reference made to flights which show typical or important results in each category.

Flight 5: Released from Alamogordo, New Mexico, 0517 MST, June 5, 1947
Recovered at Roswell, New Mexico

In this flight, a 55-pound load was lifted with a linear array of 28 350-gram rubber balloons. By attaching the balloons at 20-foot intervals along the load line, a total length of about 600 feet was required. The train is shown in Figure 1. For altitude control, three lifting balloons

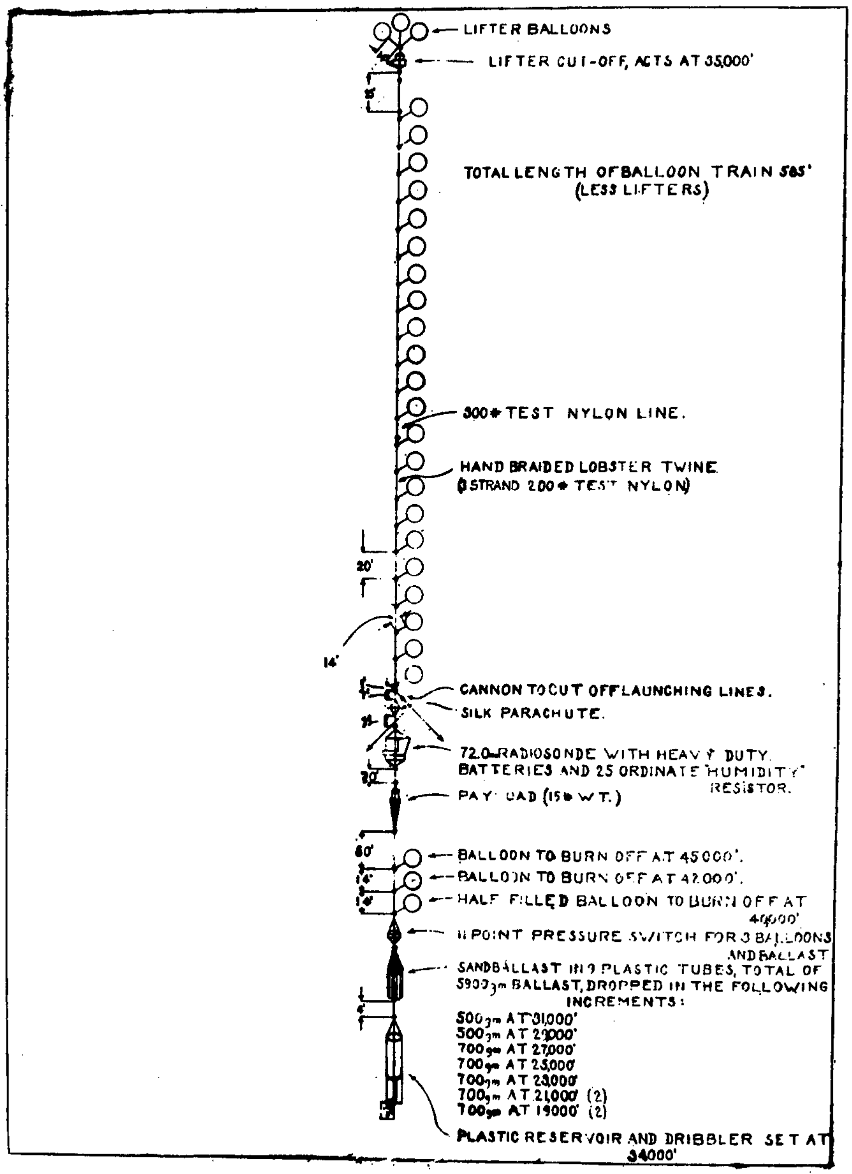


Figure 1: Train, Flight 5

were cut free at 35,000 feet, and the remaining load was weighted to balance at that point. As a precaution against over-buoyancy, three more balloons were to be freed at 40,000, 42,000 and 45,000 feet. The use of sand ballast, to be dropped in increments upon descent to altitudes below 31,000 feet, was supplemented by an early model of the automatic ballast valve set to expend liquid ballast at 34,000 feet.

From the height-time curve of the flight (Figure 2), it will be seen that the maximum altitude reached was much above the predicted 35,000 feet. Also

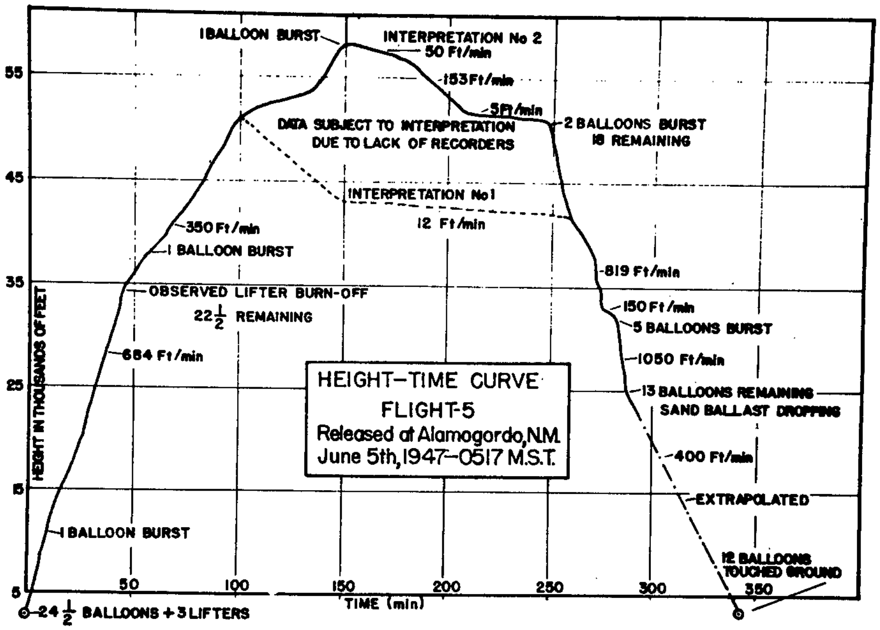


Figure 2

the rate of rise was greater than expected. Both of these evidences of excess buoyancy are attributed to superheating of the balloon by sunshine. The real height is somewhat in doubt because the conventional radiosonde baroswitch (Army type ML-310/)was used, and the pressure signal which was transmitted was ambiguous at some points.

On this flight theodolite readings were taken until the balloon was 90 miles away from release point after 260 minutes of flight. In addition, visual observations were taken from a B-17 aircraft which circled the balloon for most of the flight.

Flight 7: Released from Alamogordo, New Mexico, 0509 MST, July 2, 1947
Descended at Cloudcroft, New Mexico

Using a cluster array (Figure 3) of 13 350-gram rubber balloons and four larger lifting balloons, a 53-pound load was carried aloft on this flight. At 35,000 feet, the desired floating level, the lifter balloons were cut free.

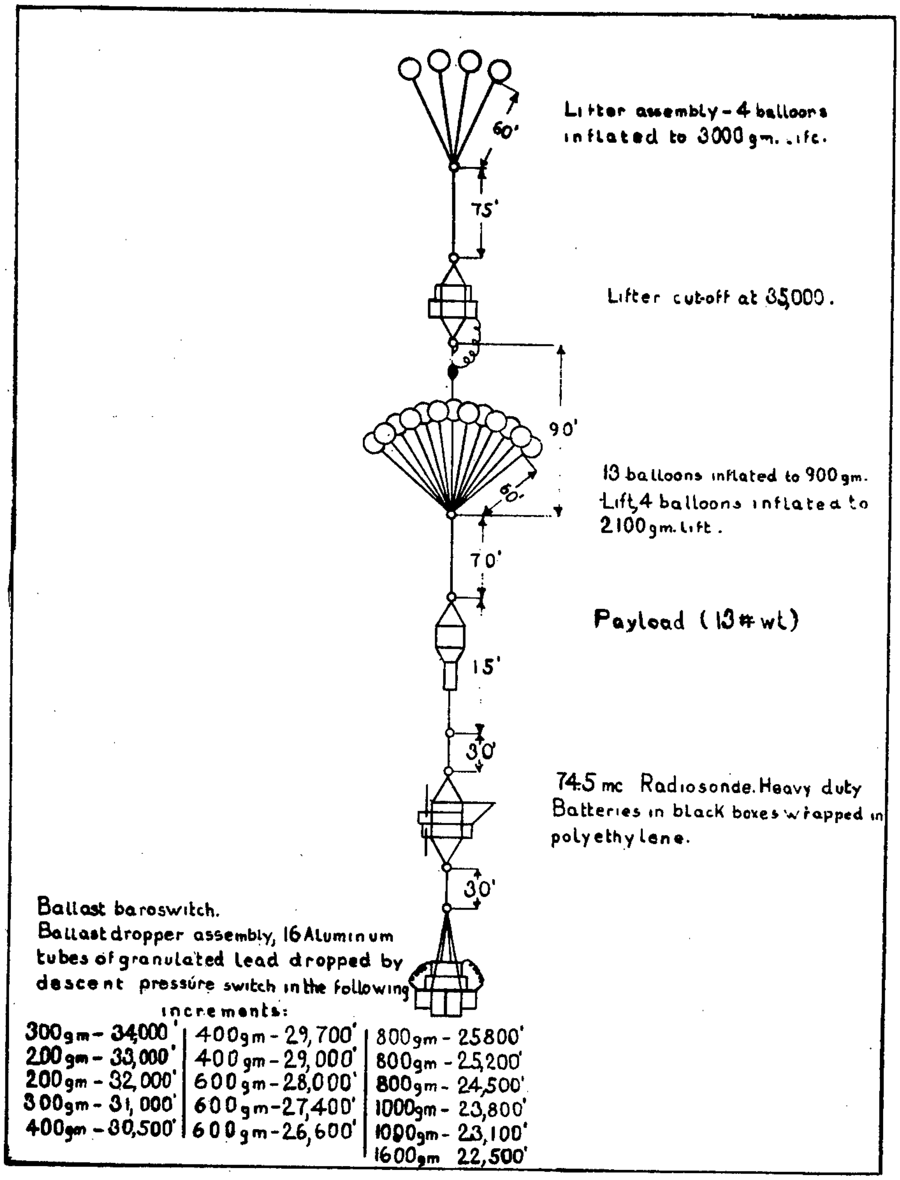


Figure 3: Train, Flight 7

When the train began to descend below 34,000 feet, lead shot was dropped in increments to maintain buoyancy.

This altitude-control system operated well enough to produce a height-time curve (Figure 4) with one descent checked by ballast dropping. Too much weight was lost in this action, and the train rose until some of the balloons were burst. Subsequent descent was not checked.

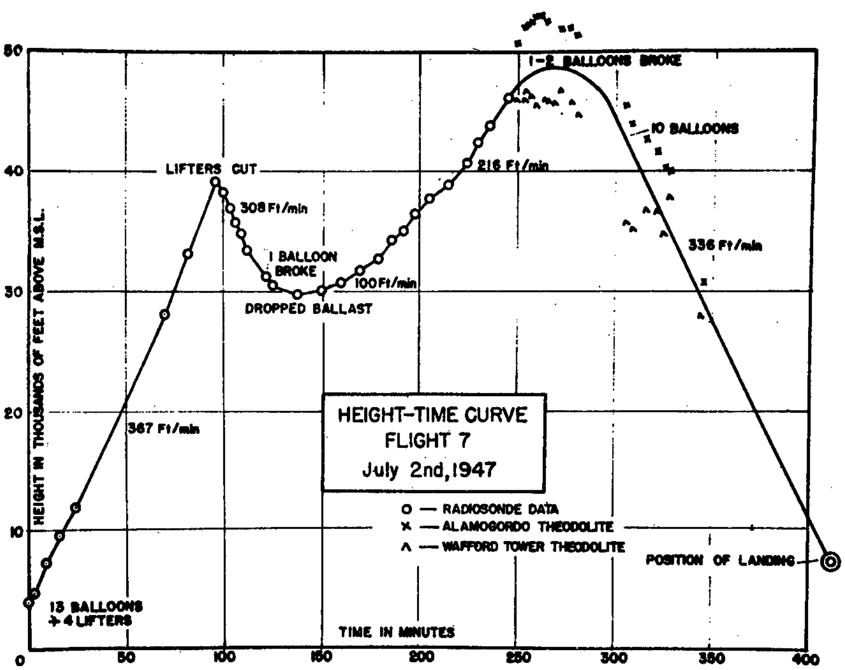


Figure 4

From this flight it appears that the inherent instability of freely extensible balloons is so great that no simple control will cause them to remain at one pressure level.

Tracking for the entire flight period was accomplished with a C-54 aircraft. Two theodolite stations were operated, one at the launching site and one at Wafford Lookout, a fire tower about 20 miles northeast of the release point.

Flight 10: Released from Alamogordo, New Mexico, 0501 MST, July 5, 1947
Not recovered

This flight was the first to use a large plastic balloon as the lifting vehicle. The cell was spherical, 15 feet in diameter, and the walls were .008" polyethylene heat sealed at the seams (made by Harold A. Smith, Inc.). The altitude control was an automatic ballast valve, pressure-triggered to throw off liquid ballast. The equipment train used on this flight is shown in Figure 5.

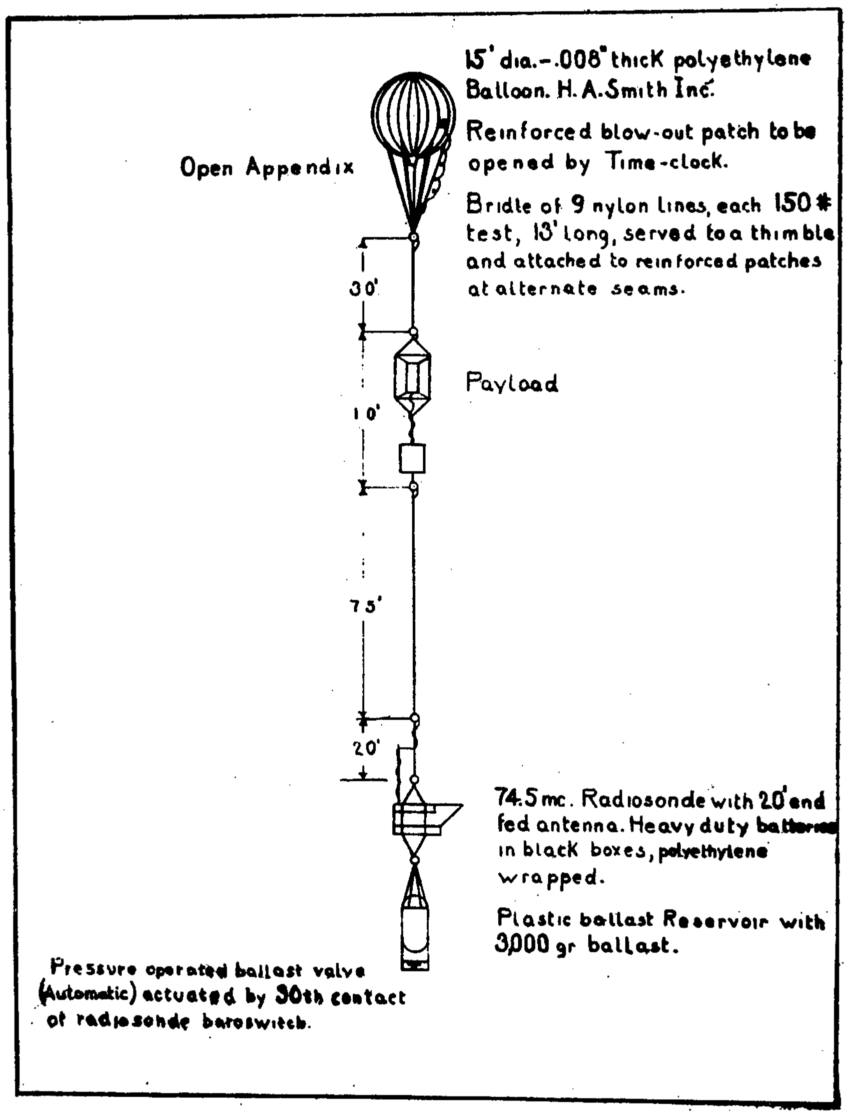


Figure 5: Train, Flight 10

The balloon rose to about 16,000 feet MSL and dropped back to 9000 feet MSL where it "floated" for at least 4 hours, at which time radiosonde reception failed. It is believed that the automatic ballast valve sealed off properly at 12,000 feet, but the air entrapped in its aneroid was heated and caused the operating level to be at the lower value. This would correspond to a superheat of 30°C above the air temperature.

Later flights showed that the type of load attachment used on this balloon was unsatisfactory; however, with proper rigging, cells of .008" thickness were good vehicles as they usually showed very low diffusion and gas leakage.

Near the end of the recorded data, the height-time curve shows large oscillations about a pressure plane (Figure 6). Three factors which probably

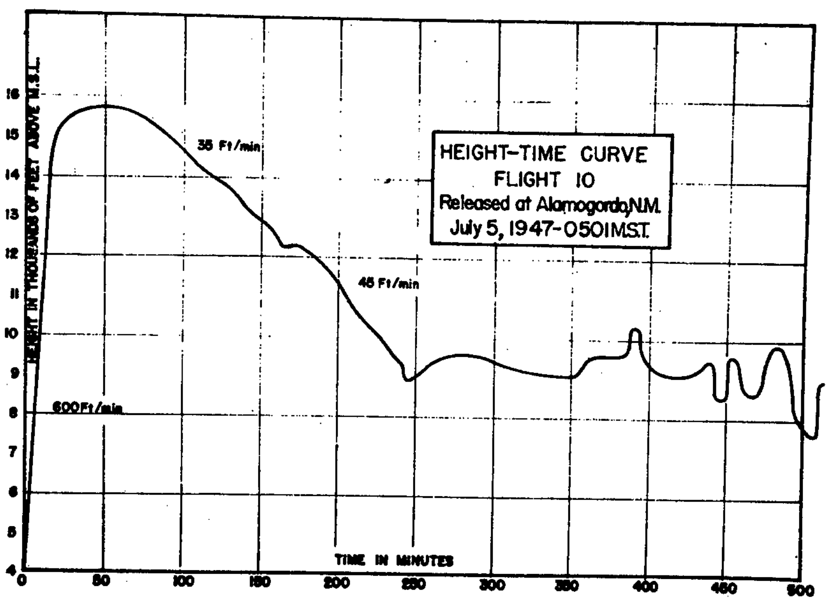


Figure 6

contributed to this instability were: (1) the turbulent motion of the heated air over the desert, (2) the changes in temperature of air in the aneroid valve as intermittent clouds shut off the sun, and (3) the overcompensation caused by the valve-controlled ballast flow.

On this flight the first "destruction device" was used for the purpose of bringing down the balloon after a fixed time to prevent excessive interference in air-traffic lanes. This particular model was a clock-driven device which failed to operate, probably because of low temperatures causing unequal contraction within the movement. Its action was to consist of detonating an inflammable compound taped to the balloon, rupturing its side and permitting a rapid escape of the lifting gas.

Flight 11: Released from Alamogordo, New Mexico, 0508 MST, July 7, 1947
Not recovered

On this flight a 15-foot, .008" wall, polyethylene balloon was combined with a cluster of six small plastic cells (7-foot diameter, .001" wall) to lift a total load of 35 pounds as high as possible (Figure 7). The small

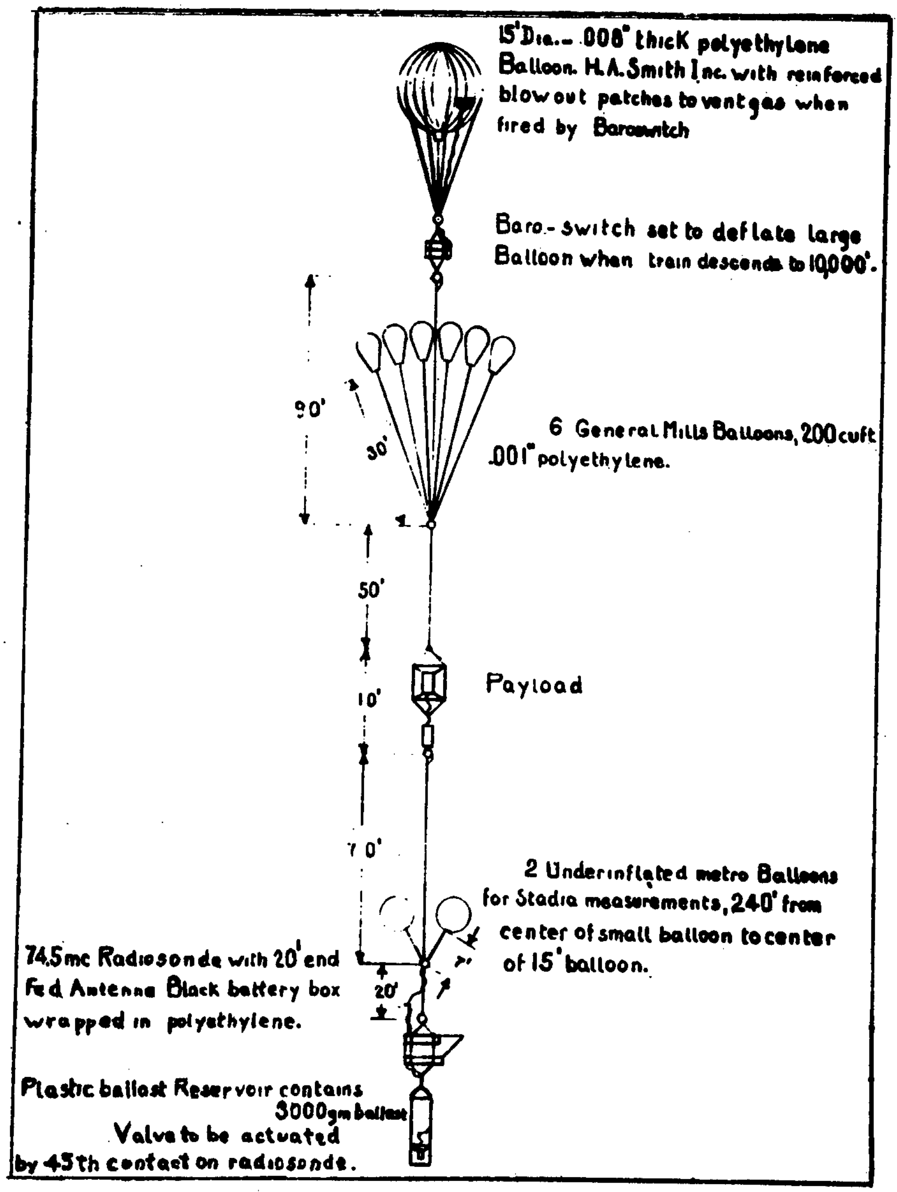


Figure 7: Train, Flight 11

cells did not rise as fast as the large balloon; consequently, three of them were inverted and filled with air.

With this loss of lift, the altitude reached was only about 17,000 feet MSL, and the automatic ballast valve (set to operate at 45,000 feet) was not activated. This flight demonstrated the need for a minimum-pressure switch to activate the ballast valve. A fixed ballast leak of about 400 grams per hour was caused by a defective valve fitting and this was sufficient to maintain the balloon at nearly constant level until all the ballast was exhausted. Following this experience, the use of a preset fixed leak was employed on many flights.

The very unstable "floating" seen on Flight 10, when the automatic ballast valve controlled the flight, is not found on this flight where the vehicle used only a fixed-leak control. This eliminates both the over-compensation and the serious effects of temperature changes on the aneroid capsule, which are found when the automatic ballast valve is used.

The trajectory of this balloon (Figure 8) shows a very interesting deformation at the transit of the Sacramento Mountains. The anti-cyclonic

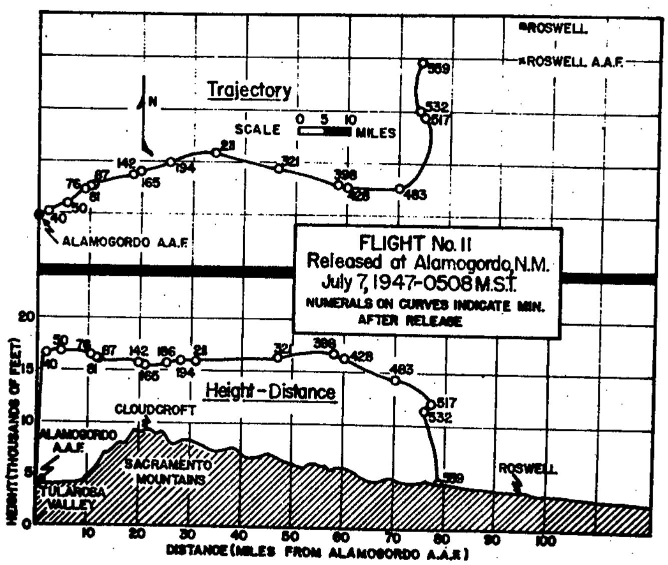


Figure 8

curvature over the eastern slope suggests that the air stream at the floating level was distributed by the terrain, and the deformation predicted by dynamic theory may thus be given a physical illustration. The trajectory was determined by aircraft and theodolite observation.

Another striking feature of the flight is the disagreement between the actual flight path and the trajectory which might have been estimated from routine upper-wind reports. Reports from El Paso, Roswell, Albuquerque and White Sands were used for comparison with the observed trajectory. Except for White Sands, none of these stations reported any wind from the WSW at or near the floating level during the 12-hour period covered by the flight. At White Sands a very shallow current was detected moving in the direction indicated by the balloon flight. This clearly demonstrates the non-representiveness of the ordinary pilot balloon observation.

Flight 12: Released from Lakehurst, New Jersey, 0714 EST, August 5, 1947
Recovered at Smyrna, Delaware

This flight saw the first use of several new items. The balloon was the first .001" polyethylene cell flown; a 397 mc(T-69) transmitter was flown, with radio direction-finding equipment used to track the balloon; a 3 mc (AM-1) transmitter was tested for the first time and the first model of a minimum-pressure switch was provided to activate the automatic ballast valve. The equipment train for this flight is illustrated in Figure 9.

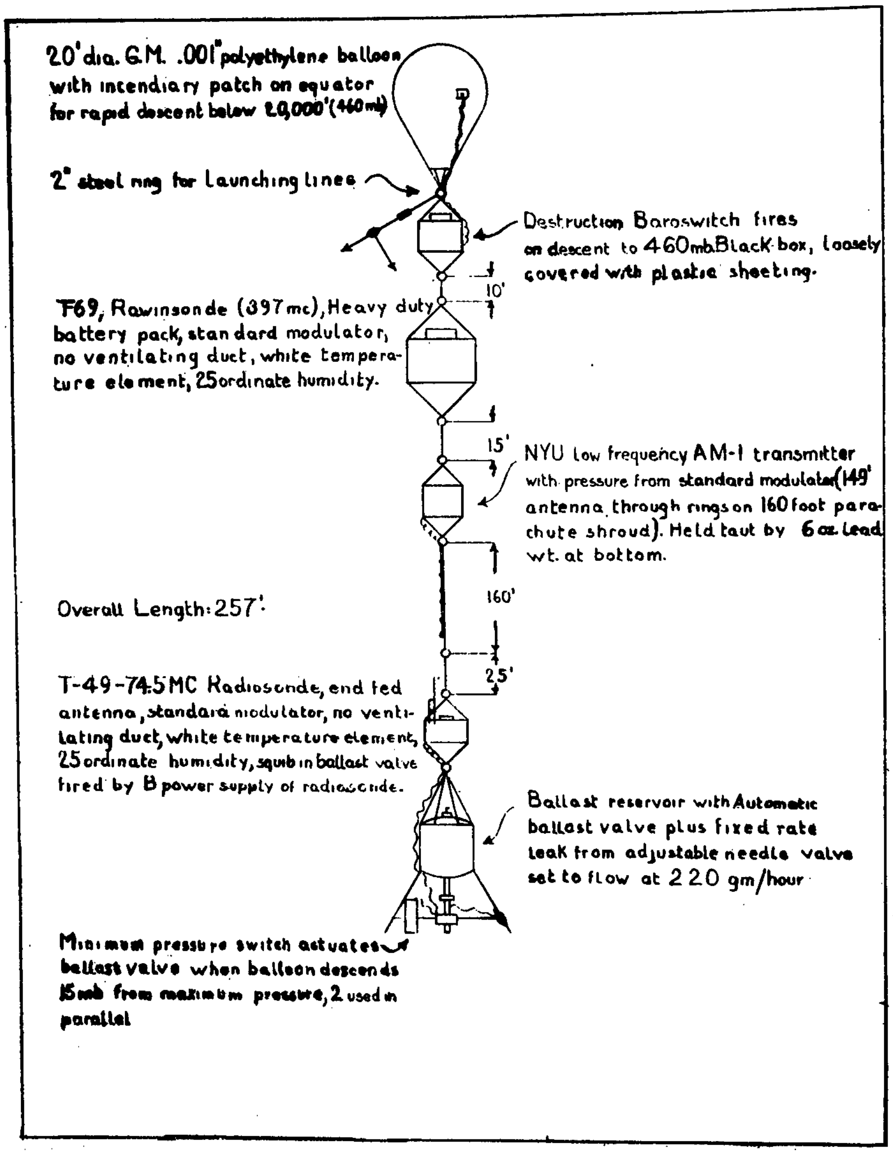


Figure 9: Train, Flight 12

Measurements in the hangar prior to release indicated that lift losses from leakage and diffusion were about 200 grams per hour, and in addition to the automatic ballast valve system, a fixed-flow needle valve was set to discharge ballast slightly in excess of the expected loss. Both systems failed to keep the balloon afloat, and a slow descent from its maximum altitude of 14,000 feet MSL resulted. The expected altitude of 38,000 feet was not reached, and this is believed to be due to mixing of the air with the lifting gas during rising. The bottom of the balloon was open with no protecting skirt or valve to keep out air. Since the thin fabric would rupture with an internal pressure of 0.017 psi, some form of skirt or external appendix was suggested for future flights.

Radio reception with the 3 mc transmitter was excellent and far surpassed the performance of either the 72 mc or 394 mc transmitters which were also flown.

Because of the low elevation angle of the transmitter, the single SCR-658 radio direction-finding equipment was not of much use for positioning. Tracking by aircraft was satisfactory throughout the flight.

Flights 13, 14, 15, 16 and 20: Made in September, 1947, they had as their primary purpose the testing of external balloon appendices to prevent excessive dilution of the lifting gas with air.

On three of these flights the loose polyethylene tubes twisted shut during the balloons' ascent and caused the cell to burst as it became full. The unsatisfactory models tried are seen in Figure 10, as well as the skirt

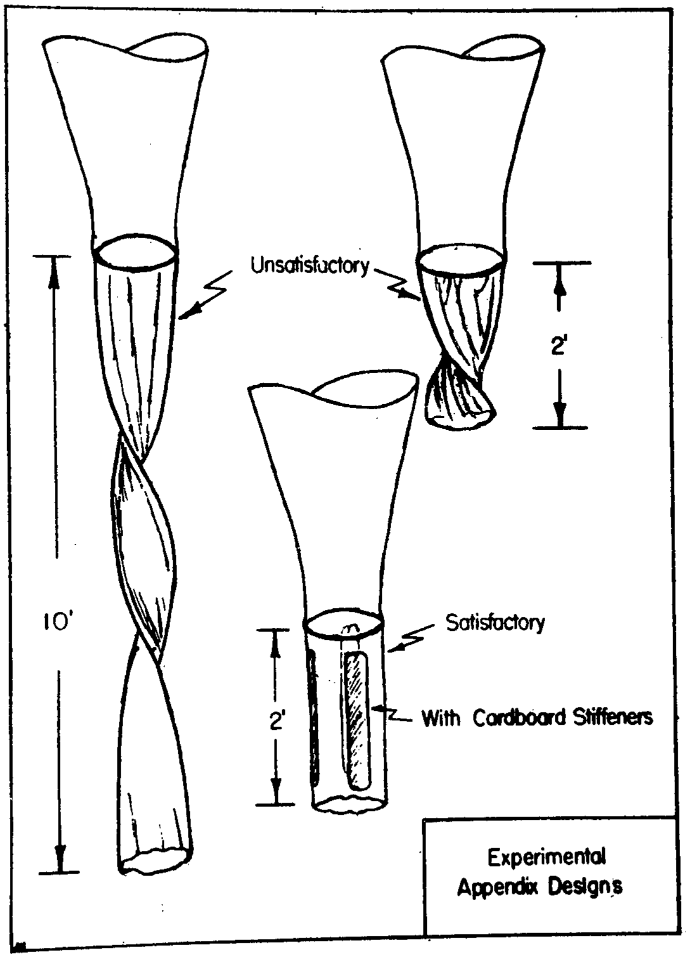


Figure 10

stiffened with external battens which was developed on Flight 20 and used successfully thereafter.

On most of these flights, radio direction-finding equipment (SCR-658) was used, as well as theodolite and aircraft for tracking and positioning the balloons. A system of air reconnaissance and ground recovery was developed using a radio-equipped jeep to move cross-country at the direction of the aircraft observer. Several satisfactory recovery missions were made on these and later flights using this technique.

Flight 17: Released from Alamogordo, New Mexico, 1647 MST, September 9, 1947
Recovered at Croft, Kansas

On this flight the first balloon made of .004" polyethylene was launched. The altitude controls were a fixed-flow needle valve orifice set to leak at 100 grams per hour and an automatic ballast valve activated by a minimum-pressure switch.

This flight reached floating level shortly before sunset, and the balloon took on superheat which was lost when the sun went down. This cooling necessitated the rapid discharge of ballast to maintain buoyancy. The operation of the automatic ballast valve at this time was satisfactory and restored the balloon to a floating level within one hour. Following restoration a satisfactory floating performance was indicated for as long as radio contact was maintained (Figure 11). The need for a balloon-borne

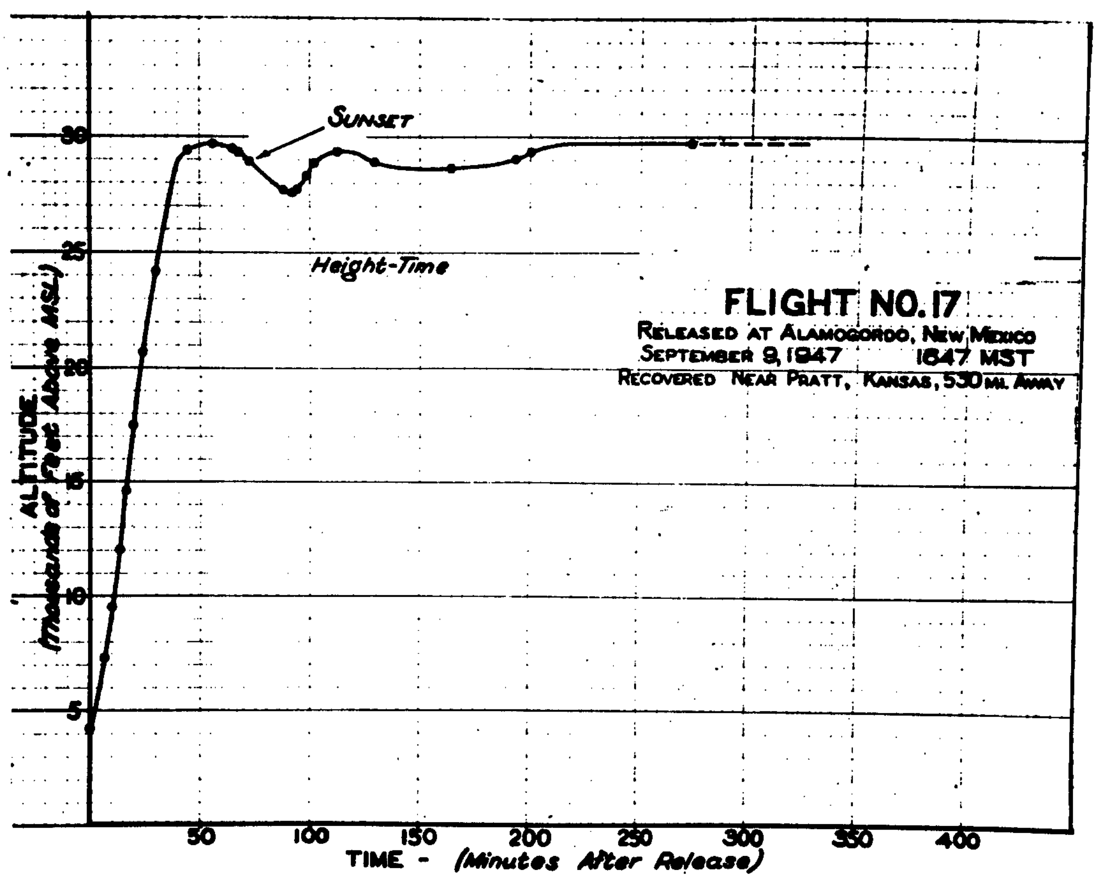


Figure 11: Height-time curve, Flight 17

barograph was demonstrated by this flight which traveled more than 500 miles from the release point.

<u>Flight 23:</u> Released from Alamogordo, New Mexico, 0918 MST, September 12, 1947
Not recovered

A J-2000 neoprene balloon was encased with a nylon shroud and provided with a valve to permit gas to escape after a small superpressure ($\frac{1}{4}$" of water) was exceeded. The balloon in its shroud is shown in Figure 12.

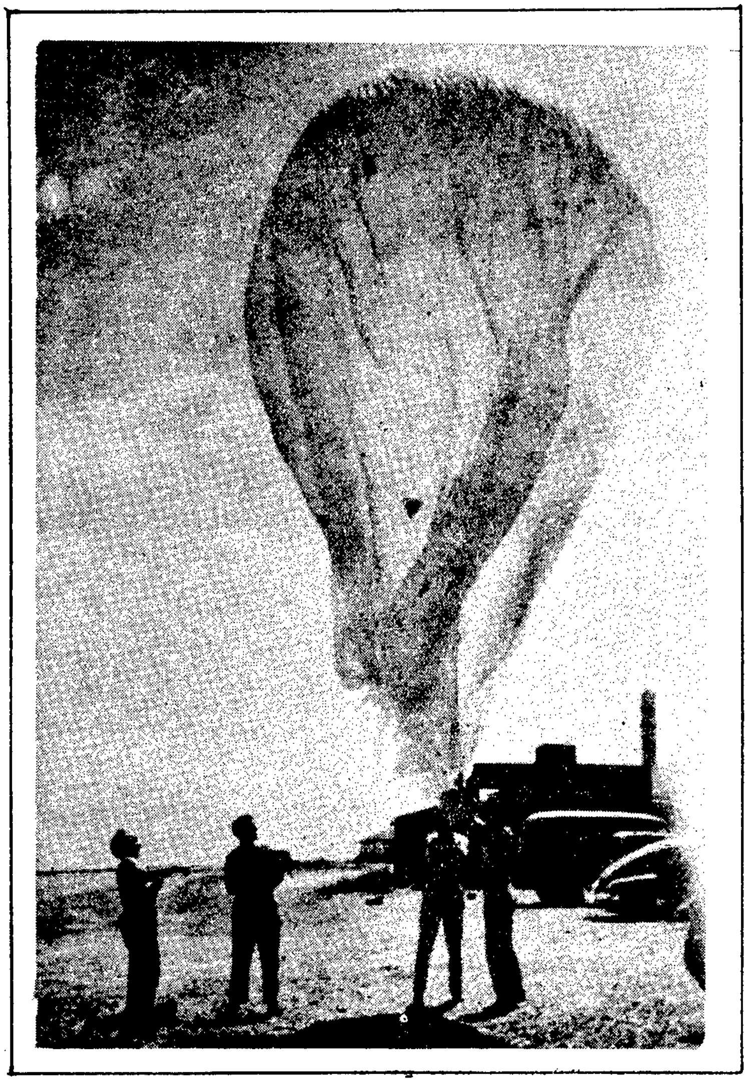


Figure 12: Neoprene balloon encased in a nylon shroud

If a "superpressure" balloon is used, much less ballast is required since, during minor oscillations, the reduction of buoyancy will not cause the balloon to descend as long as the remaining buoyancy is equal to or greater than the load supported.

This balloon, and three similar ones (Flights 38, 66, 87), failed to achieve any constancy of altitude. All four failed during the rising period or soon after the shroud became full. (The balloons were heated prior to release to restore elasticity.)

Flights 29 through 39: They were made from Alamogordo, New Mexico during November and December, 1947 to test ballast controls and to develop a launching technique satisfactory for high winds. The period of data reception by radio was too short in all of these flights to permit much evaluation of the altitude controls. On three flights (33, 35 and 39) a Fergusson meteorograph was added to the train to record flight pressure; of 11 balloons released, only these three were not recovered.

On seven flights the pressure signals received by radiosonde were lost while the balloon was still rising; Flight 38 was a shrouded neoprene balloon which burst as it became full; and Flight 39 was a polyethylene balloon which burst at or near its ceiling following a very rapid rise. (This was the first balloon to burst using a short external appendix with stiffeners.)

On the other two flights (30 and 35) a very short period of level flight was recorded before the balloon-borne radio transmitter passed out of range.

Besides these two, several other .001" polyethylene balloons probably were maintained at constant or near-constant levels for several hours, as can be seen from their points of recovery (Figure 13). One balloon was seen descending 18 hours after release.

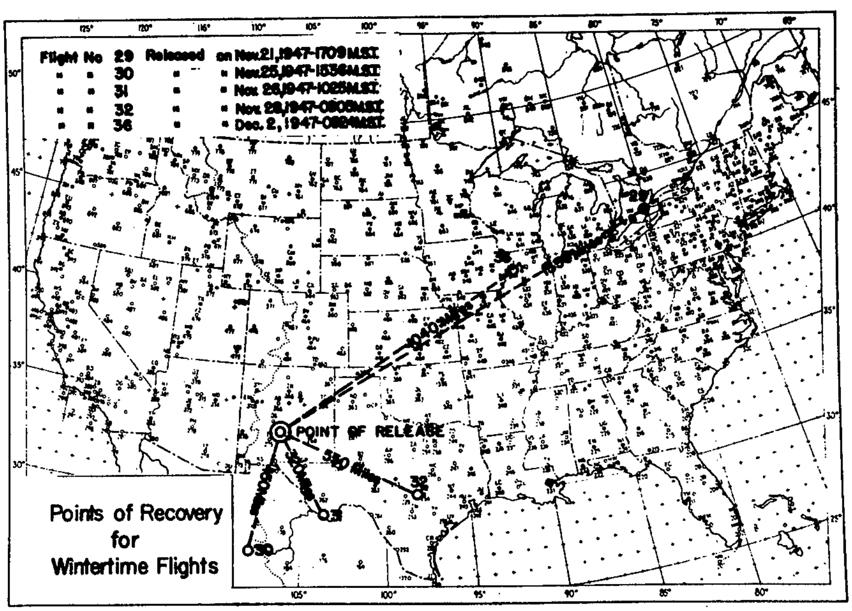


Figure 13

On Flights 29 through 33 only a fixed ballast leak was used, set for flows of from 300 to 600 grams per hour. Other flights used automatic ballast controls. Although these fixed leaks seemed to be sufficient to keep the balloons aloft, there was no clear evidence as to what amount would be needed for most efficient operation. The need for a system of ballast metering was indicated in this series of flights.

Flight 41: Released from Indiantown Gap Military Reservation, Pennsylvania, 0956 EST, February 16, 1948
Not recovered

The balloon was of .001" polyethylene and had a fixed-leak ballast control set to provide a constant flow of 650 grams per hour. The principle objective of this flight was to test aircraft reception from a balloon-borne transmitter. Using RDF equipment, two B-17 planes were able to receive clear signals from the transmitter at least 150 miles away from it and were able to home in on the signal by using the radio compass. There was a questionable zone of about a 15-mile radius beneath the balloon, and it is probable that this represented a cone of silence from the vertical antenna. The balloon was near 40,000 feet with the planes at about 10,000 feet.

On later flights, using a frequency of 1746 kc, reception range was extended to over 400 miles and no cone of silence was encountered. By flying along the bearing indicated by the compass until it abruptly reverses, the position of the balloon may be determined. Visual observations confirmed the presence of the balloon overhead.

On service flights made from this same base during this week, two new pieces of flight gear were added to the train. The first of these was a cloth parachute, mounted upside down in the line to serve as a drag, acting against excessive rates of rise. When mounted above the cloth identification banner, this chute also acts to minimize sway and lateral oscillation of the equipment.

The second unit was a new type of destruction device--a pressure-activated mechanism by which a large hole is ripped in the balloon upon descent into the lanes of air traffic. In this device (Figure 14) the equipment is permitted to fall freely for a few feet, jerking a length of line through the balloon side. After this fall, the equipment again is carried by the main load line, and the ruptured balloon acts as a parachute to lower the gear to the ground at about 1000 feet per minute.

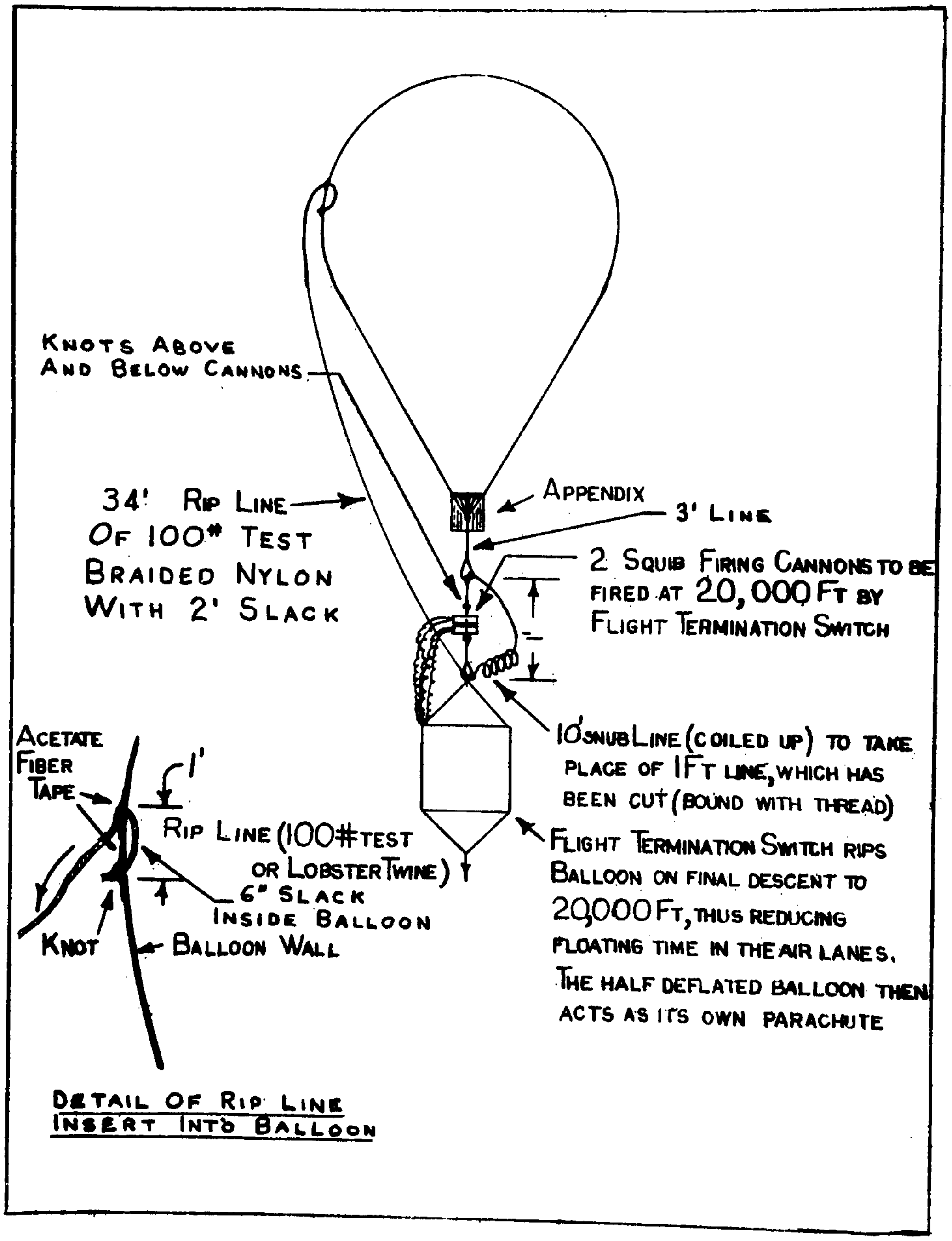


Figure 14: Rip-out line in place on balloon

Flight 43 through 51: In April, 1948 a number of flights were made using .001" polyethylene balloons and fixed-leak ballast controls. Only four of these flights were recovered. The landing points of these are shown in Figure 15.

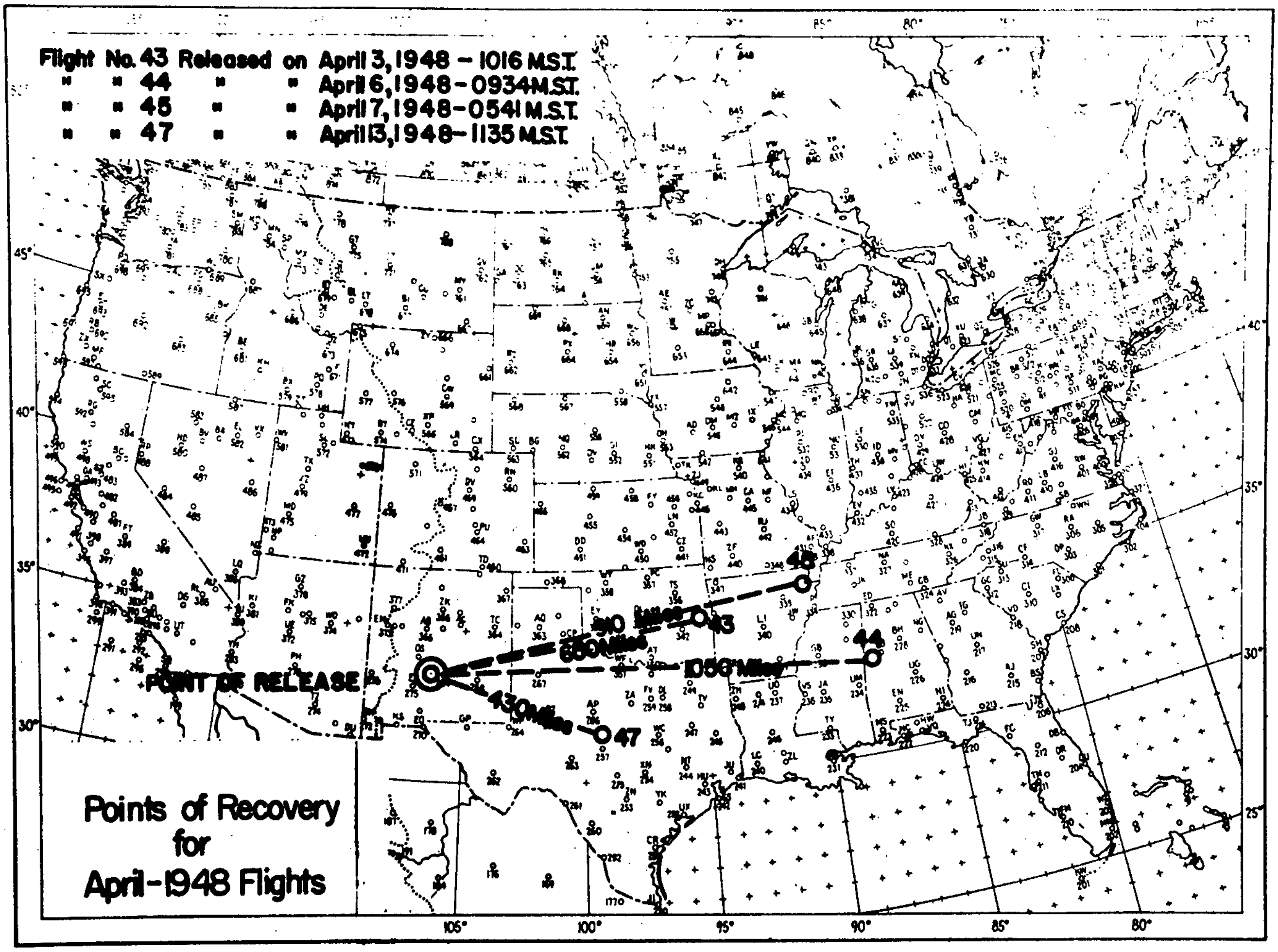


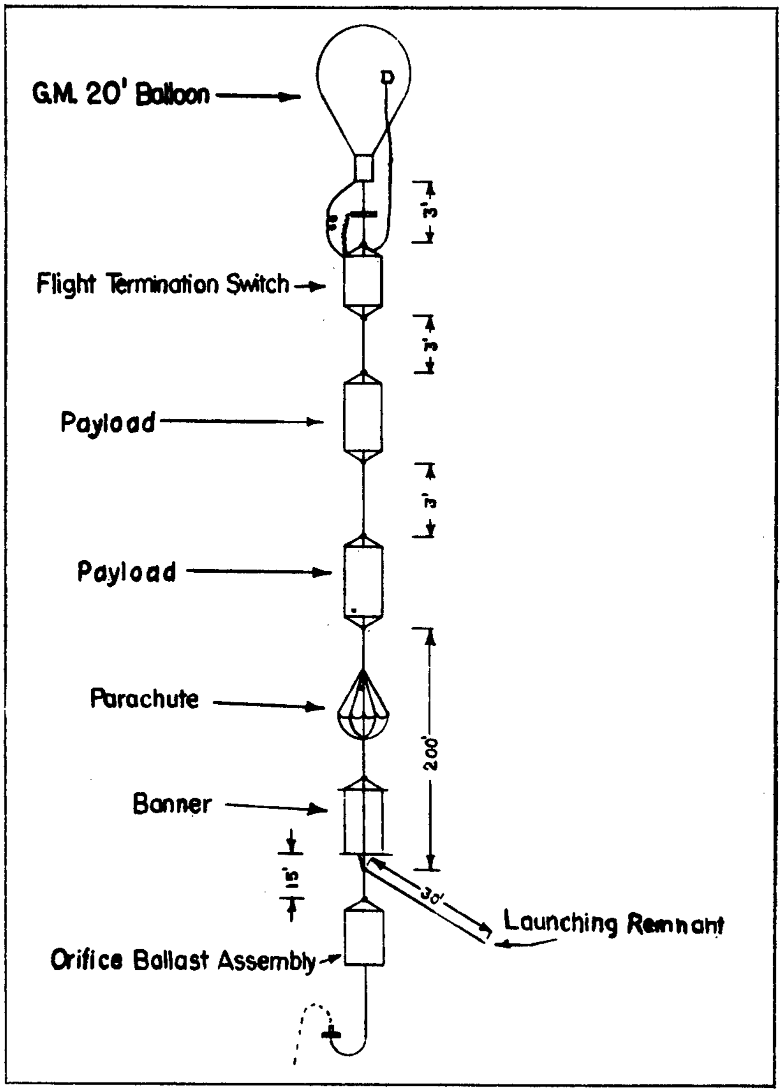
Figure 15

Little is known positively about the floating levels since radiosonde data was not obtained on most flights, and no barographs were available. Three receiving stations at Alamogordo, Roswell and Carlsbad, New Mexico were used to position the balloon with radio direction-finding equipment. By assuming a floating level corresponding to the load, several flight patterns were derived. No aircraft tracking was provided to check these computed trajectories.

On these flights fixed ballast leaks of from 250 to 600 grams per hour were used. These leaks were provided through round orifices rather than through needle valves which had been in use previously. This improvement reduced the possibility of clogging.

On Flight 43 the first model of an Olland-cycle pressure modulator was flown with a modified T-69 (400 mc) radiosonde transmitter. The results obtained on this flight were not satisfactory, but later test proved successful.

The train seen in Figure 16 is typical of those flown during this period. Note the presence of the device to rip the balloon when descending into air lanes and thus speed up its fall.



Flight 16: Train, typical of those flown in April, 1948

Flight 52: Released from Alamogordo, New Mexico, 0958 MST, April 23, 1948
Recovered at Galseburg, Kansas

On this flight a .001" polyethylene balloon carried the first model of the Lange Barograph and an improved Olland-cycle pressure modulator to give improved radiosonde pressure data. The signal from the radiosonde was lost soon after the release, but the barograph was recovered and the altitude record is shown in Figure 17. It will be seen that the balloon rose to a

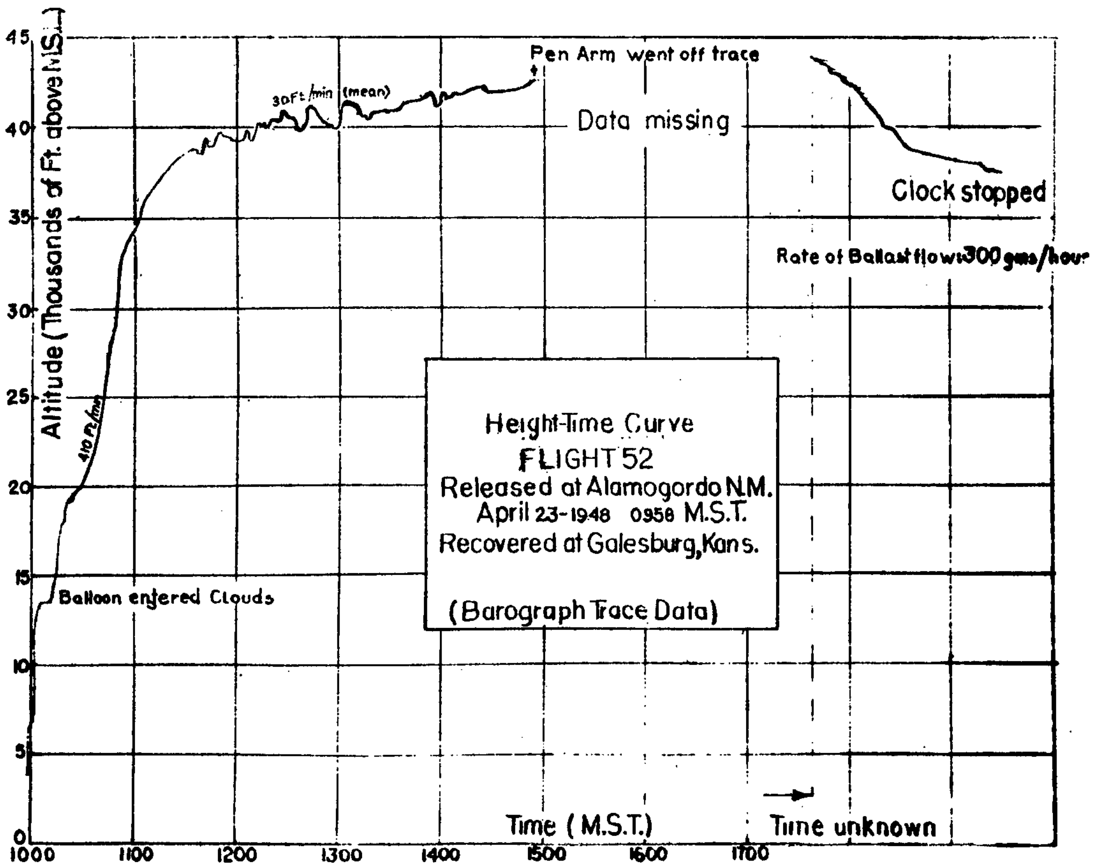


Figure 17

pressure such that the barograph pen passed off the chart, and several hours of flight were not recorded. The slowly rising ceiling seen here was the first long-period confirmation of the expected behavior of a balloon controlled by a constant ballast loss. The flow in this case was set for about 250 grams per hour, and the altitude change was about 400 feet per hour. This rise of "ceiling" is somewhat larger than predicted and heightened the interest in obtaining temperature measurements so that the buoyancy behavior could be more exactly determined.

Three other points of interest may be seen on this barotrace: (1) The two very pronounced step effects found on the rising portion of the flight at about 625 mb and 480 mb correspond to stable layers in the atmosphere as seen from the El Paso radiosonde sounding taken at 0800 MST (Figure 18).

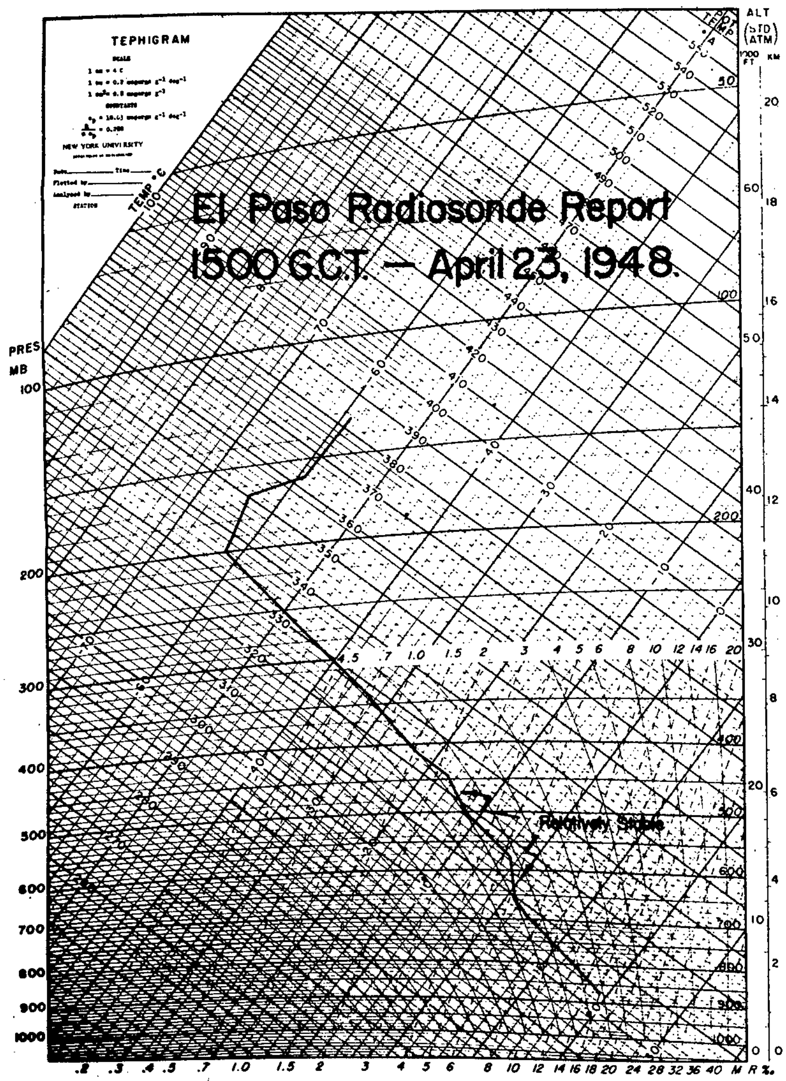


Figure 18

(2) The clock of the barograph stopped after being exposed about 10 hours at cold temperature. (3) During the floating period many small oscillations are seen on the pressure record. Neglecting superheat changes, there is no variation in the forces of the balloon system except the constantly decreasing weight of ballast and the monotonic loss of lifting gas, and these oscillations must, therefore, be attributed to some force in the atmosphere.

Flights 54, 56 and 60: On these three flights, made in April and May, 1948, fixed-leak ballast losses were used to keep a .001" polyethylene balloon aloft, but no barograph record of pressure is available. From the descent points (Figure 19) and the radiosonde data which was received it is believed that the ballast flows of about 300 grams per hour were adequate.

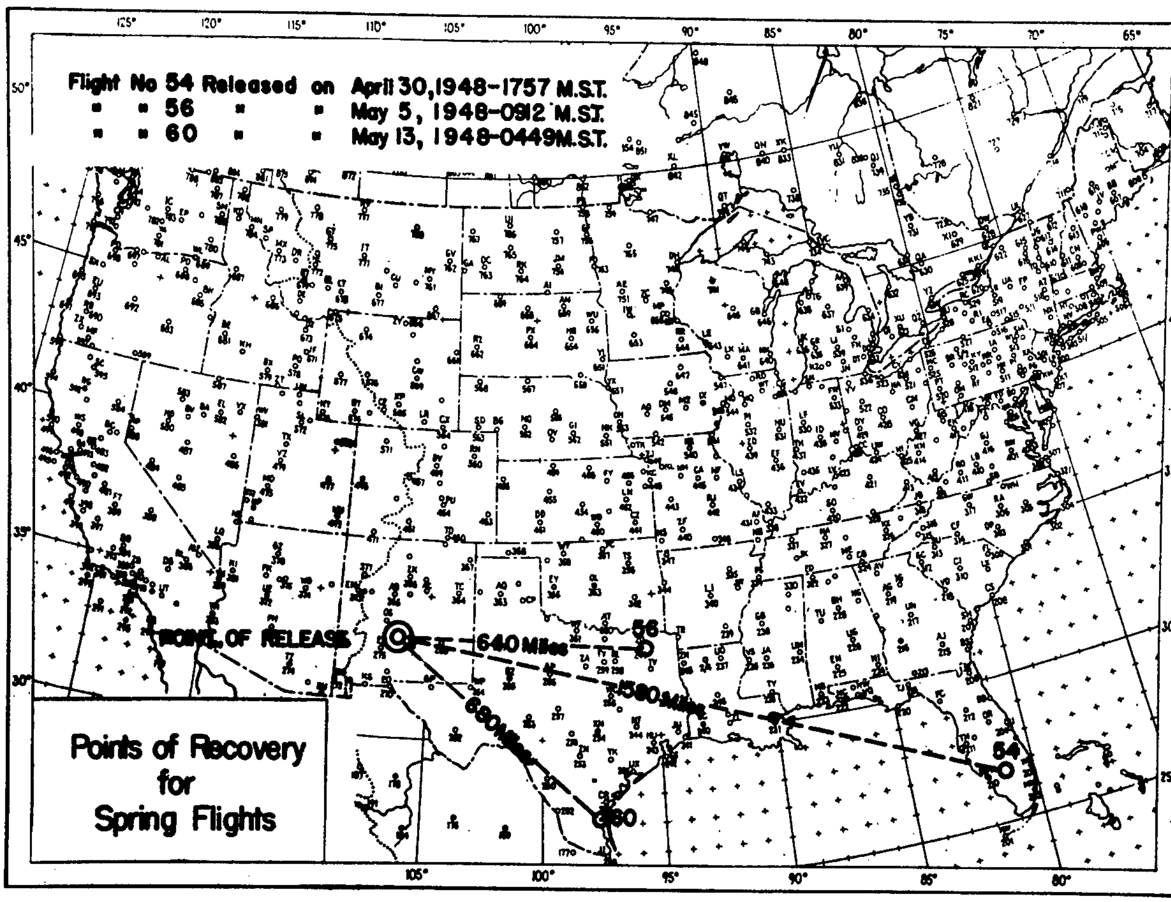


Figure 19

On both Flights 56 and 60 a very light load was lifted, and the floating level in each case was over 60,000 feet MSL. Light winds were encountered in both cases, and a reversal from Westerlies to Easterlies was experienced near the floating level on Flight 60. With a relatively slight change in elevation, the balloon passed from Westerlies (below) to Easterlies (above) with the result that the balloon was still visible from the launching site (Alamogordo, New Mexico) at sunset, $14\frac{1}{2}$ hours after released. The finder reported seeing the balloon descend 35 hours after release.

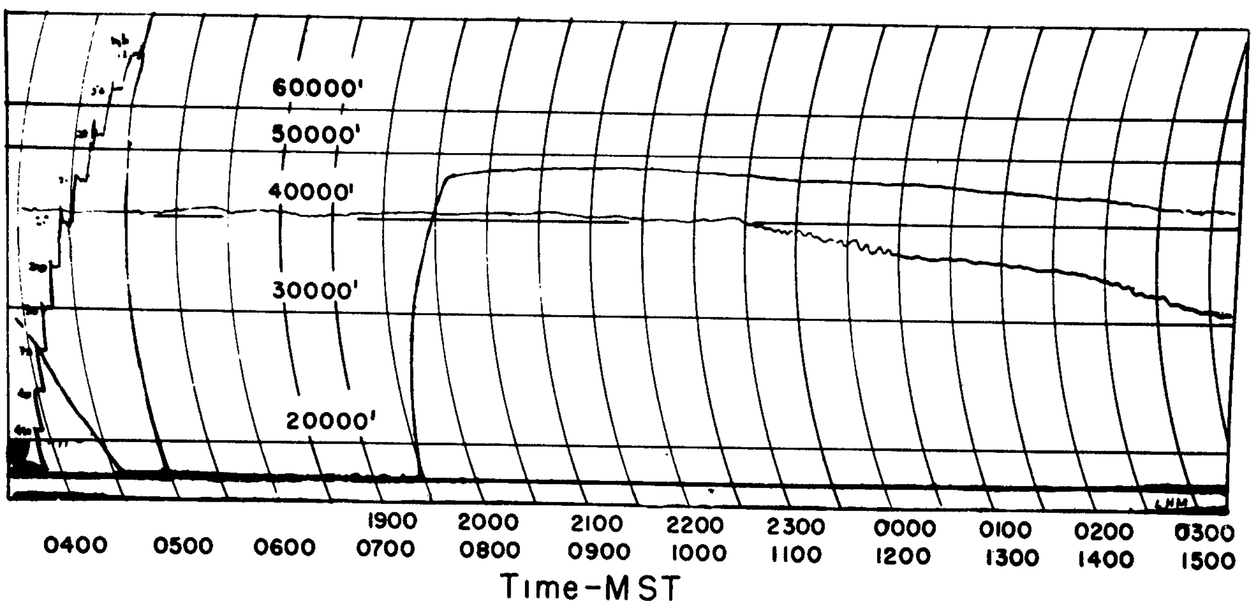
Since the ballast flowing to maintain buoyancy would have been exhausted in only 5 hours, this flight provided the first evidence that such a balloon in the stratosphere maintains buoyancy much longer than at lower levels. The two factors which contribute to this are the heat added to the helium by adiabatic compression when descending and the diminished diffusion of lifting gas at a low pressure.

On Flights 56 and 60, a three-station network was set up to receive pressure signals on radio direction-finding (SCR-658) equipment. In addition, theodolites were used for several hours in each case.

Flight 55: Released from Alamogordo, New Mexico, 1907 MST, May 3, 1948
Recovered at Northeast, Pennsylvania

On this flight a barograph was flown, and a satisfactory Olland-cycle pressure modulator was also used for over 5 hours to give height data. The length of time of signalreception is significant, since the battery box of the transmitter was not insulated, and there was no heat to be gained from the sun during this nighttime flight. The .001" polyethylene balloon was observed descending 22 hours later after traveling more than 1500 miles.

The altitude control used on this flight was an automatic ballast valve, activated by a minimum-pressure switch, and as evidenced by the barogram in Figure 20 (12-hour rotation), the balloon maintained its altitude for over



NYU BALLOON PROJECT FLIGHT 55
Barograph Record Of G.M. 20 Ft. Balloon With
Automatic Ballast Valve
RELEASED AT ALAMOGORDO, N.M., 1907 MST- 3 MAY, 1948
RECOVERED AT NORTHEAST, PA., 4 MAY, 1948
DURATION 23 HOURS

Figure 20

15 hours before beginning its accelerating descent. On this flight record, marked oscillations are observed at three points. Despite the presence of automatic ballast controls which might cause oscillatory motion, these rises and falls must be attributed to atmospheric disturbances since the magnitude of the forces required to produce such accelerations is far greater than any which could be supplied by the control equipment.

A check against the trajectory and end point of the balloon flight was made by a group of graduate students of meteorology at New York University. By constructing constant-pressure maps from the appropriate radiosonde data, the expected trajectory was computed assuming the balloon would move with the geostrophic wind. The results of this comparison (Figure 21) show that the balloon tends to move across the isobars toward lower pressure.

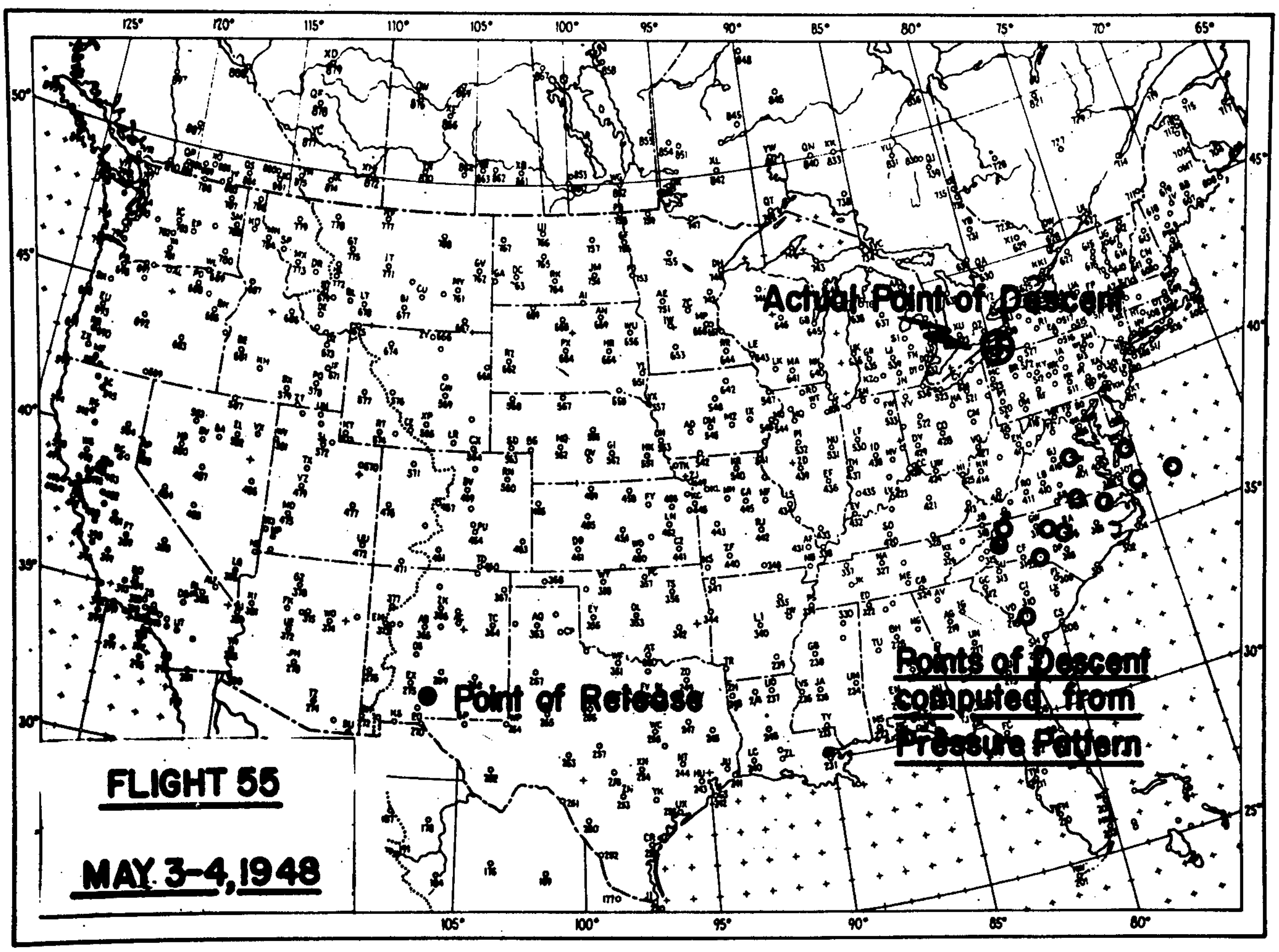
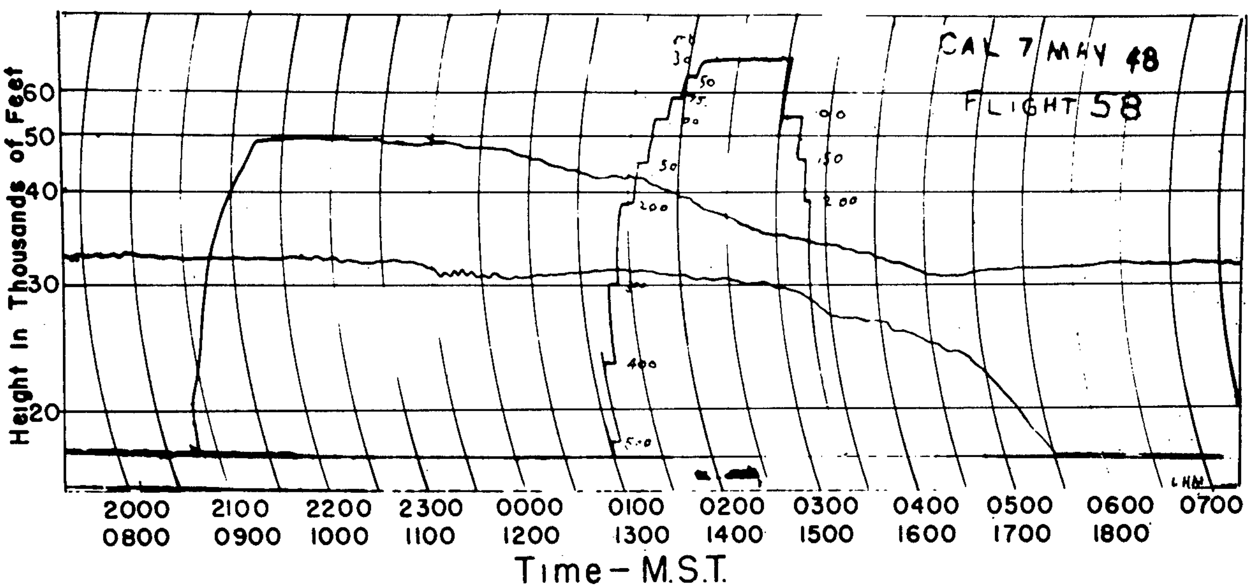


Figure 21

Flight 58: Released from Alamogordo, New Mexico, 2033 MST, May 10, 1948
Recovered at Val D'Or, Quebec

A .001" polyethylene balloon was the vehicle on this flight carrying a barograph as well as an early model of the Olland-cycle pressure modulator. This flight was released at night with a fixed ballast flow of about 300 grams per hour expected to keep the balloon afloat. From the barogram (Figure 22) (12-hour rotation) it appears that the orifice did not permit sufficient (if any) flow to maintain buoyancy during the first several hours (perhaps the orifice was clogged or frozen). After a descent to about 33,000 feet at sunrise a floating level was maintained with 4 kilograms of ballast available. The full flow rate could not have been maintained much more than the 11 hours during which the balloon was at this pressure.



NYU BALLOON PROJECT FLIGHT 58
Barograph Record Of G.M. 20 ft. Plastic Balloon With
300 gm/hr Fixed Ballast Leak
RELEASED AT ALAMOGORDO, N.M. - 2033 MST, 10 MAY, 1948
RECOVERED AT VAL D'OR, QUEBEC, CANADA - 24 MAY, 1948
ESTIMATED DURATION - 24 1/2 hrs.

Figure 22

On this flight, oscillations in the pressure record were seen. With no control system which could cause such behavior, they must be attributed to atmospheric motion.

The descent point was compared with that expected from analyses of the pressure field. The results of a number of such analyses are shown in

Figure 23. As on Flight 55, the balloon appears to have moved across the isobars, toward lower pressure.

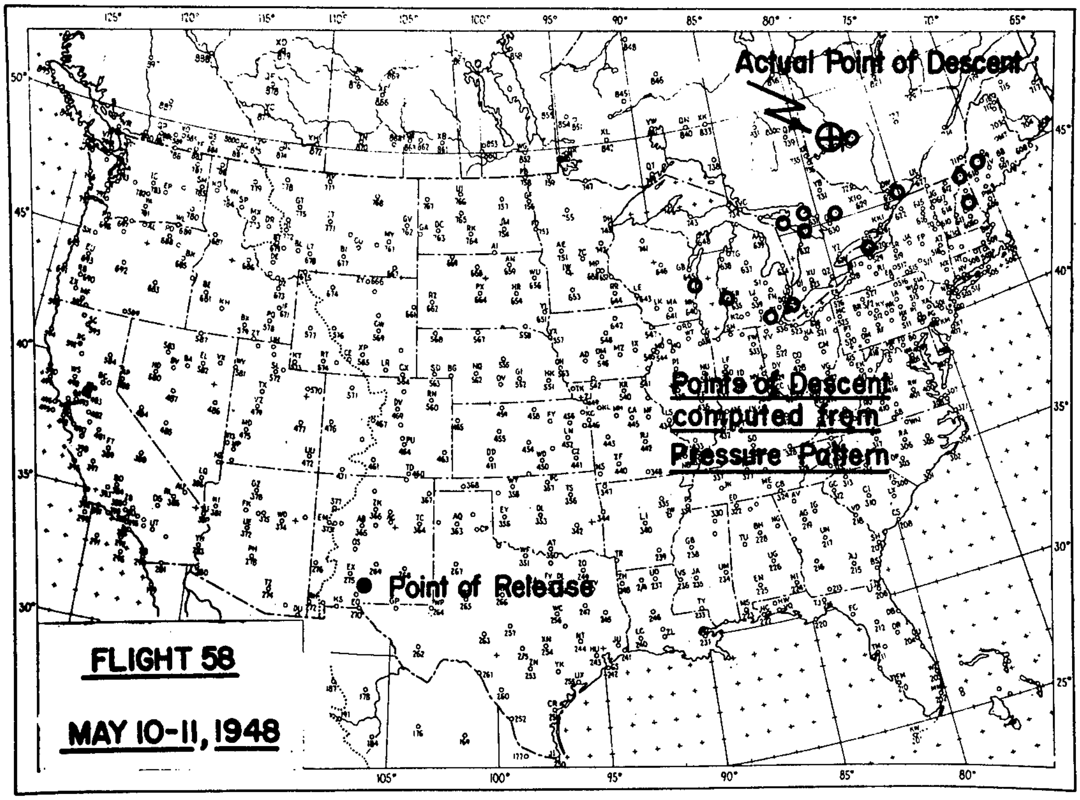


Figure 23

Radio direction-finding tracking (SCR-658) was used during the first 367 minutes of this flight. This was made possible by a strong output from the battery, indicating that no harmful effects were experienced in the cold atmosphere despite the absence of solar radiation. The need for measurements of the temperature of the batteries was suggested by this flight.

Flight 63: Released from Alamogordo, New Mexico, 1116 MST, May 13, 1948
Descended at Alamogordo, New Mexico

On this flight a Seyfang Laboratories balloon, made of neoprene-coated nylon, was flown with a valve in the appendix set to open after an internal pressure of 0.02 psi was built up. On an earlier flight (59) such a balloon was flown with no valve but an appendix held closed with a rubber band; it ruptured upon becoming full.

Both a constant ballast-flow orifice and an automatic ballast control were used to keep this balloon buoyant. In addition to the ballast, a surplus of buoyancy might have been acquired when superpressure was built up inside the cell. Despite these controls, the balloon began to descend after a short period of floating, and its descent was not checked (Figure 24).

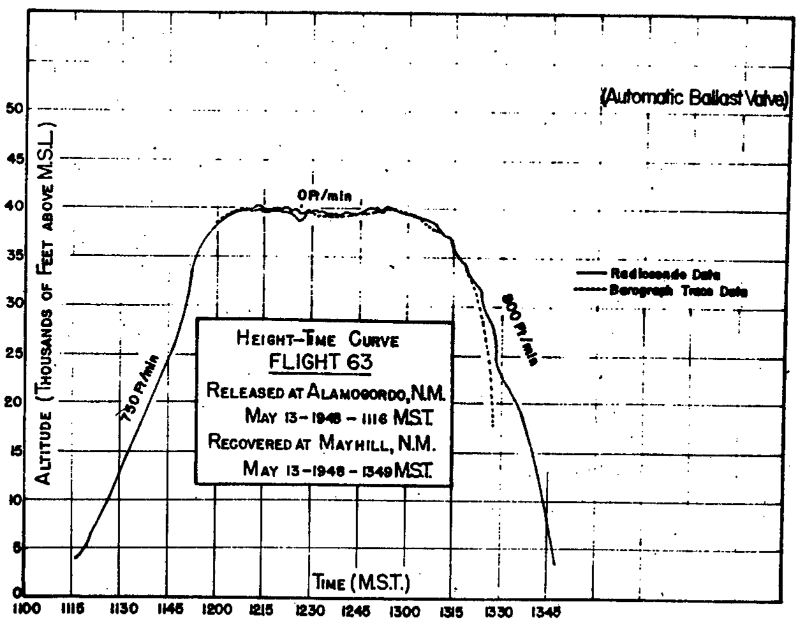
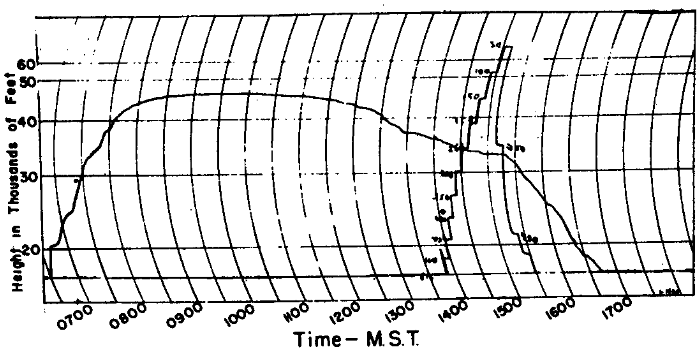


Figure 24

An analysis of the acceleration which could be gained from a loss of superheat indicated that if the coated fabric had absorbed radiation and gained 50°C over the outside air, the superheat thus obtained would be so great that its subsequent rapid loss (as by ventilation) could not be compensated for even with the ballast flowing at full rate. To improve the analysis of balloon flights, a measure of the temperature difference between lifting gas and air temperature was suggested.

<u>Flights 68 through 72:</u> In July, 1948 this series of flights was made without ballast controls to determine the natural buoyancy of the General Mills, Inc. 20-foot .001" polyethylene balloons. Of five such flights, only two good barograph records were obtained, one daytime flight (70) and one night flight (71). In both cases a nearly constant level was maintained for about four hours at the highest altitude reached.

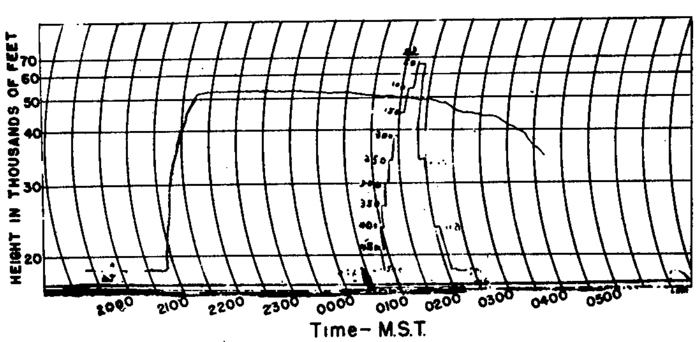
On the barogram of Flight 70 (Figure 25) a section of arrested descent may be noticed, preceded and followed by a nearly constant fall. The cause of this step is not apparent, although a check has been made of the atmospheric structure of that day.



NYU BALLOON PROJECT FLIGHT 70
Showing 20' General Mills Balloon
Performance When No Ballast Was
Dropped
RELEASED AT HOLLOMAN AFB, N.M.–JULY 8, 1948
0633 MST – RECOVERED AT KENT, TEXAS

Figure 25

On Flight 71 marked oscillations are seen at the floating level and also during the descent portion of the barogram (Figure 26). Clearly these must represent atmospheric motions since no controls of any sort were in use. There is no reason to believe that rapid changes in superheat occured, since the floating level was far above the cloud level. Also the flight was made at night and no sunshine was encountered.



NYU BALLOON PROJECT FLIGHT 71
Barograph Record Of G.M. 20 Ft. Plastic Balloon Showing
Balloon Performance When No Ballast Was Dropped.
RELEASED AT ALAMOGORDO N.M., 2042 MST – 9 JULY, 1948
RECOVERED AT VALENTINE TEXAS, 10 JULY, 1948
ESTIMATED DURATION 10 HOURS

Figure 26

Flight 73: Released from Alamogordo, New Mexico, 1948 MST, July 14, 1948
Recovered at Lincoln National Forest, New Mexico

The objective of this nighttime flight was to determine whether a fixed ballast leak of 100 grams per hour would sustain a 20-foot, .001" polyethylene balloon at floating levels near 50,000 feet. From the Olland-cycle pressure record (Figure 27) it appears that loss of buoyancy due to

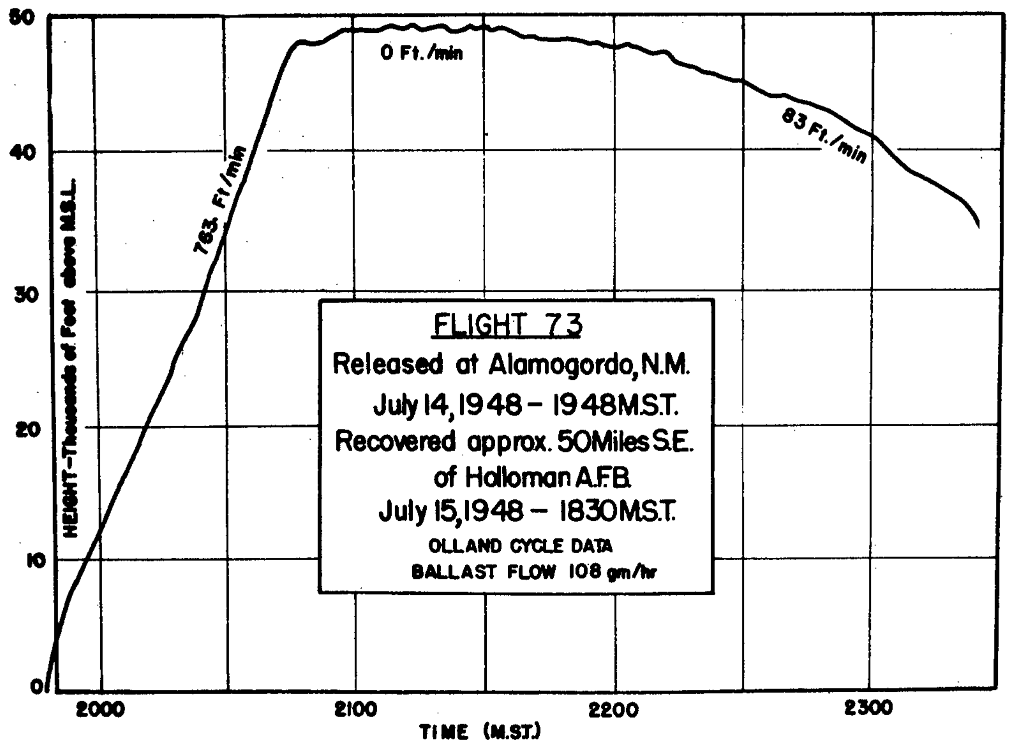


Figure 27

diffusion and leakage is more than this. Indeed, the balloon with this ballast flow did not remain at altitude as long as either Flight 70 and 71 which were without altitude controls.

Flight 74: Released from Alamogordo, New Mexico, 1040 MST, July 19, 1948
Not recovered

This was a test of a single 7-foot balloon made of .001" polyethylene, carrying a 4-kilogram payload. One part of the load was the first model of an automatic ballast siphon used to detect and telemeter the amount of ballast being discharged through an automatic ballast valve.

The balloon flew at 7000 feet MSL across a heated desert area and into a mountain pass whose elevation was about 6000 feet MSL. During the first two hours its behavior was reported by radio, and the accompanying time-height curve (Figure 28) shows how the ballast valve operated successfully

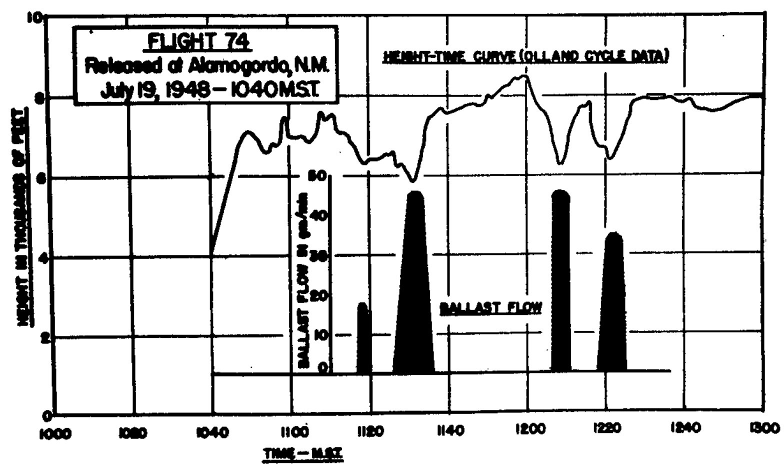


Figure 28

to sustain the balloon. During this turbulent flight about 200 grams of ballast were expended per hour, but the pronounced orographic and convective currents probably necessitated more control than would be required in a more stable atmosphere.

The very useful information about ballast flow was reported clearly, and the principle of the auto-siphon was used repeatedly on later flights. Small variations are seen in the pressure at which the ballast flow began. Since the balloon was floating below the base of clouds, this represents the changes of activation pressure which resulted from changes of superheat of the air entrapped in the aneroid.

Flight 75: Released from Alamogordo, New Mexico, 1010 MST, July 20, 1948
Recovered at Hollister, California

In order to reach higher altitudes than was possible when 20-foot plastic balloons were used, a 70-foot, .001" polyethylene cell was flown on Flight 75. To determine the duration of buoyancy of this type of balloon no controls were used. Despite this, the balloon remained aloft for more than 60 hours and successfully withstood the loss of superheat occasioned by at least two sunsets. From the height-time curve of this flight (Figure 29) the very marked effect of superheat is apparent.

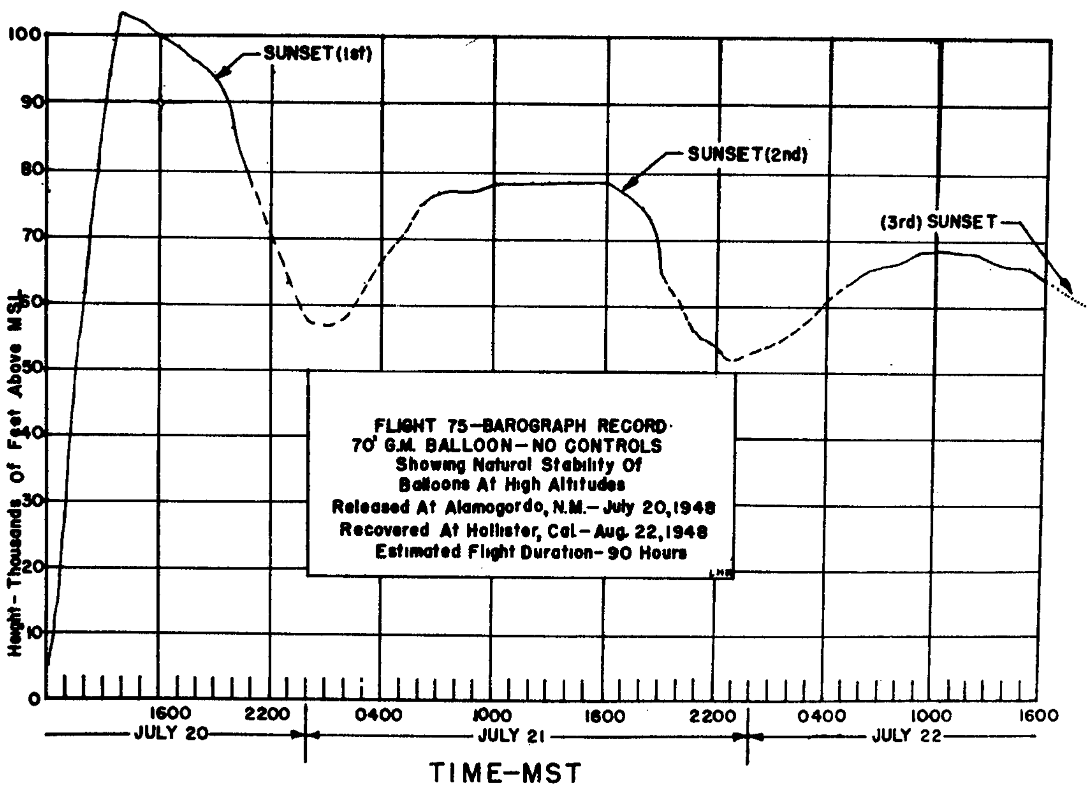


Figure 29

The record of the barograph was not complete since the clock stopped each night (clearly recording the lowest elevation reached, however) and ran down completely after 56 hours.

Since the small external appendix with cardboard stiffeners was not suitable for the large balloon, a new design with aluminum formed stiffeners (Figure 30) was used. This type of appendix closer worked well on later flights, and it is likely that the long duration of this flight may be attributed in part to satisfactory closing off of the aperture. In addition to maintenance of the purity of the lifting gas, this balloon floated in a region of very low pressure, thus reducing the loss of buoyancy by diffusion.

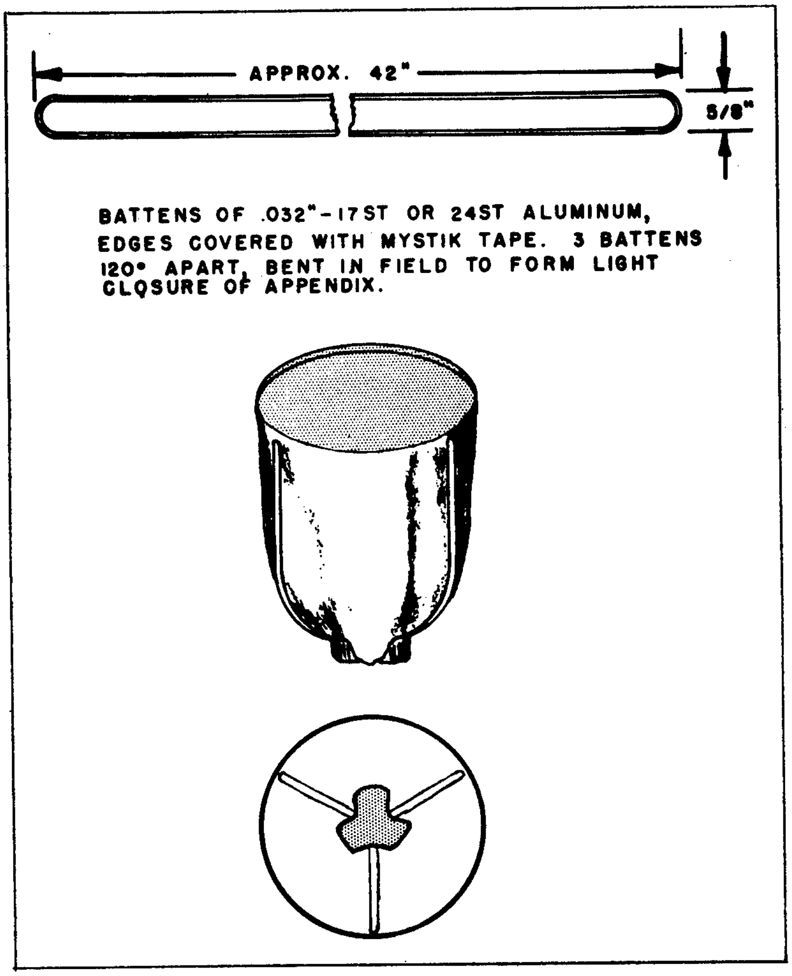


Figure 30: Aluminum battens for balloon appendix

A third factor contributing to the long flight was the heat gained by adiabatic compression of the helium during descent. In the temperature inversion of the stratosphere this adiabatic heating would add to the buoyancy by superheating the lifting gas.

From this flight it becomes apparent that the control required to maintain buoyancy at high levels is much smaller than that at low levels. On the next day, before Flight 75 had ended, a second 70-foot balloon was flown with standard automatic ballast controls, and this flight was never recovered. Presumably the marked easterly flow then observed above 60,000 feet carried this second flight into the Pacific Ocean.

Radar, RDF and theodolite were used to track the balloon.

Flight 78: Released from Alamogordo, New Mexico, 2038 MST, July 22, 1948
Not recovered

This flight was the first to be made with (white) thermistors exposed inside the .001" polyethylene balloon, inside the battery box and exposed to the air. The flight was at night and the balloon temperature was colder than the air temperature by about 5°C during the short period of time that the temperature values were telemetered. The standard SCR-658 receiver and Friez radiosonde ground station were used to record this data which was transmitted by a T-69 radiosonde. A New York University AM-1 transmitter was used to send out pressure data.

An automatic ballast valve, activated by a mercury minimum-pressure switch, was used to control ballast flow but the cold temperature presumably caused the mercury to freeze and no ballast flow was evidenced. (A ballast-metering siphon was part of the equipment.)

On subsequent flights, the minimum-pressure switch used an electrolite which can withstand the cold nighttime temperatures of the upper air.

The evidence of the thermistor in the battery box is very encouraging, since after four hours of flight the temperature remained above 10°C. This was the first measurement obtained on the cooling of batteries and indicated that no special cold temperature batteries were needed if insulation is carefully made. The temperature data and the height-time curve of Flight 78 are shown in Figure 31.

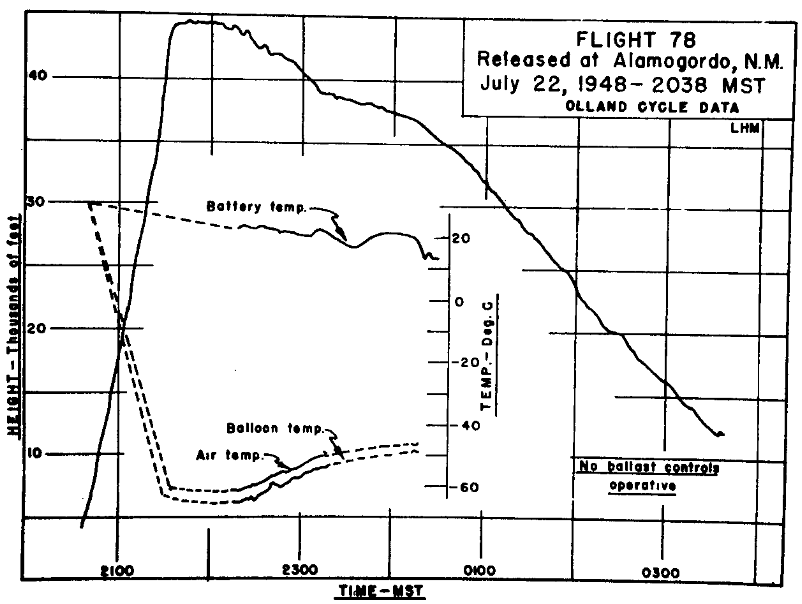


Figure 31

Flight 79: Released from Alamogordo, New Mexico, 1614 MST, July 23, 1948
Recovered at Alamogordo, New Mexico

This was the third attempt to use a coated nylon balloon, sealed off with a valve in the bottom. From Figure 32, the height-time curve, it may be seen

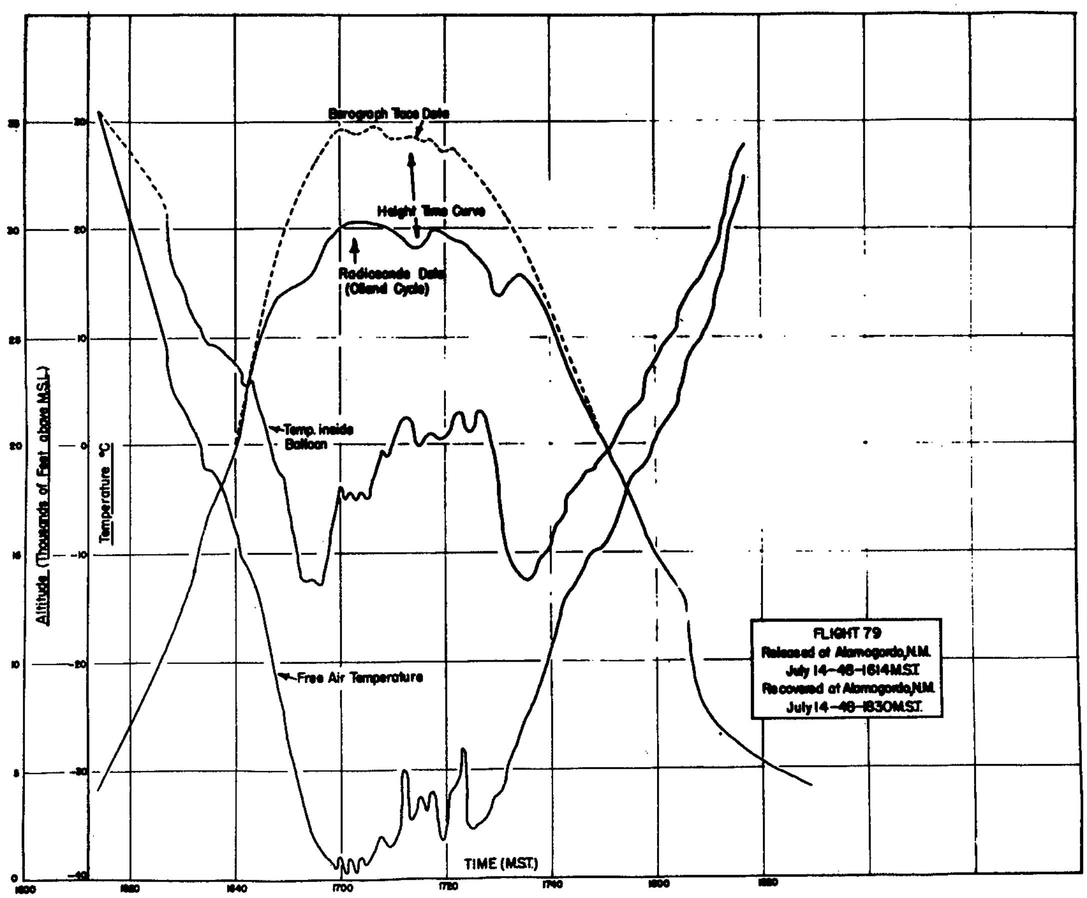


Figure 32

that this balloon did not remain aloft very long but that a high degree of superheat was generated in the lifting gas, despite the aluminum coating of the balloon.

The automatic ballast controls included in the flight equipment were inoperative, and as soon as the balloon lost its initial excess buoyancy (corresponding to the super-pressure maintained behind the safety valve) it descended. From the speed of the descent it was computed that an accelerating force equal to 5% of the gross load (52 kg) was acting to bring the balloon down. This force was in turn derived from the loss of lift encountered when over 30°C of superheat was lost by ventilation.

Flight 80: Released at Alamogordo, New Mexico, 1126 MST, July 24, 1948
Recovered at Rincon, New Mexico

On this flight an automatic ballast valve activated by a minimum-pressure switch was used to support a .001", 20-foot polyethylene balloon. From the height-time curve (Figure 33) it may be seen that the balloon remained at its maximum height for two hours, then began to descend slowly. A ballast meter was in use, and no ballast flow was recorded until the balloon descended to about 30,000 feet. It is likely that the mercury minimum-pressure switch was frozen at the higher levels, or that the squib which the switch controlled failed to detonate until a higher pressure was reached.

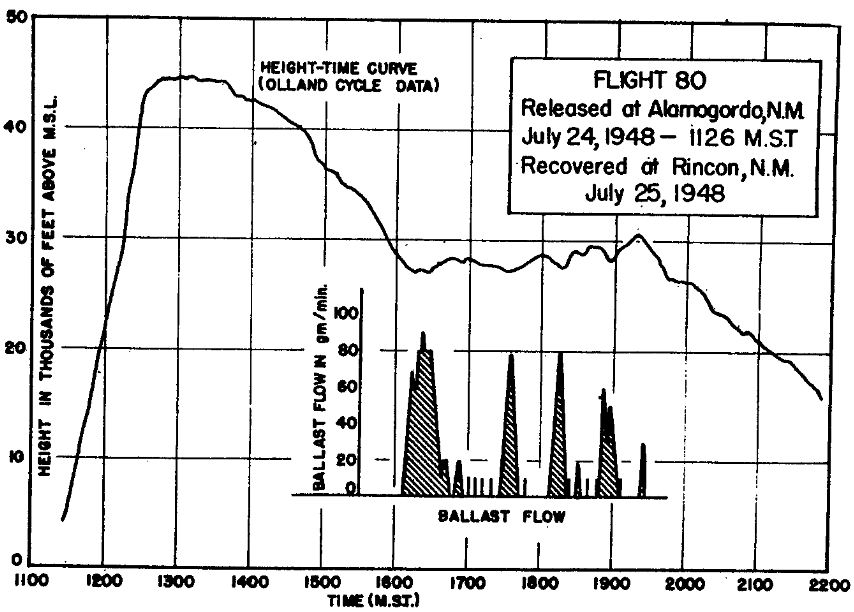


Figure 33

Following the activation of the aneroid capsule of the automatic ballast valve, ballast was released in four separate blocks. With each flow of ballast except the fourth, the balloon was returned to the seal-off pressure of the aneroid with no change in this pressure (321 mb=28,500 feet). The fourth ballast-flow period lasted until the balloon had risen to 300 mb (30,000 feet) and ballast cut off there. Since the sun had set between the third and fourth ballast-flow periods, this rise in "ceiling" is attributed to the cooling of the air entrapped in the aneroid of the automatic ballast valve. This decrease of pressure of 21 mb corresponds to a loss of 8°C of superheat. In each of the four periods of ballast flow, there was enough unnecessary ballast lost to cause an overshoot when the balloon returned to its floating level. This excess ballast was that used during the period when the balloon had begun to rise but was still below activation altitude of the automatic ballast valve. The inefficient use of ballast was one of the major objections to such a control system.

On this flight the ballast load of 3 kilograms was exhausted in only three hours, indicating a large loss of gas from this particular balloon. It is believed that the large initial acceleration provided by the rapid descent of the balloon caused the restoring force, and the subsequent overshoot, to be very large, and the high ballast flow is probably much greater than was the loss of buoyancy on this flight.

Flight 81: Released from Alamogordo, New Mexico, 0548 MST, August 6, 1948
Not recovered

The balloon flown on this flight was made of .004" polyethylene, and it was eggplant shape about 20 feet in diameter and 25 feet long. The first of its kind, this balloon was made by Goodyear Tire & Rubber Company, Inc.

Only a short period of radio reception was obtained, but during this time the balloon rose with predicted speed (500 feet per minute) nearly to its predicted altitude (40,000 feet) and floated within 1500 feet of the 37,000-foot level. Figure 34 is the height-time curve for this flight.

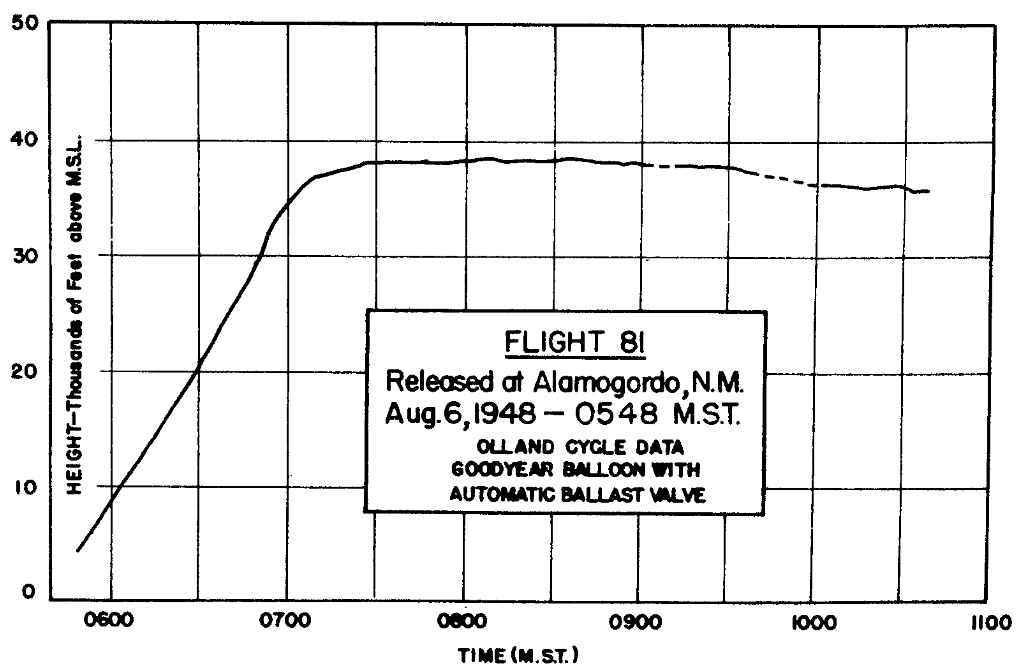
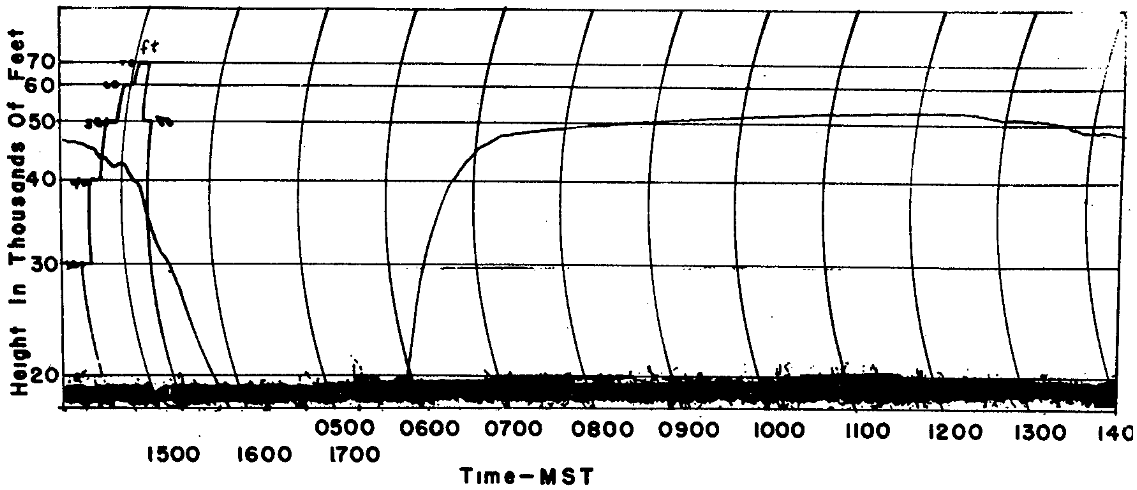


Figure 34

Since the balloon did not descend far enough below its maximum altitude to activate the minimum-pressure switch and the automatic ballast valve, no ballast flow data was telemetered while the balloon was within the radio range. This indicates a very low rate of gas loss through the walls of this balloon.

Flight 82: Released from Alamogordo, New Mexico, 0515 MST, August 10, 1948
Recovered at Roswell, New Mexico

This flight was made with a 20-foot, .001" polyethylene balloon carrying a load to 54,000 feet and sustained by a fixed-leak orifice control, expending ballast at about 525 grams per hour. With 4500 grams of ballast aboard the balloon should have been increasingly buoyant for $8\frac{1}{2}$ hours after release. From the barogram (Figure 35) it may be seen that the "ceiling" did rise, at



NYU BALLOON PROJECT FLIGHT 82
Barograph Record Of G.M. 20' Plastic Balloon With
534 gm/hr Fixed Ballast Leak

RELEASED AT ALAMOGORDO, N.M.- 0511 MST, 10 AUG 1948
DESCENDED AT ROSWELL, N.M.- 1630 MST, 10 AUG 1948

DURATION- $11\frac{1}{2}$ hrs

Figure 35

a rate of 700 feet per hour (525 grams of ballast was lost each hour), for about $7\frac{1}{2}$ hours, and then generally accelerating descent was experienced.

On this flight, radio reception was maintained for the entire air-borne period of 11 hours. Flight 82 is a good example of flight using a single fixed-leak orifice for altitude control by ballast dropping.

Flight 85: Released at Alamogordo, New Mexico, 1542 MST, August 17, 1948
Not recovered

The objective of this flight was to carry a standard radiosonde to a high level; there it was to be released on a parachute and, at the moment of release, the batteries for the transmitter were to be activated. To accomplish this a pressure-triggered switch was rigged on a .001", 20-foot polyethylene balloon. Below the baroswitch a standard T-69 radiosonde was supported with a parachute stuffed into a case also hanging from the parent balloon (Figure 36). Two plugs were set to keep the transmitter circuit

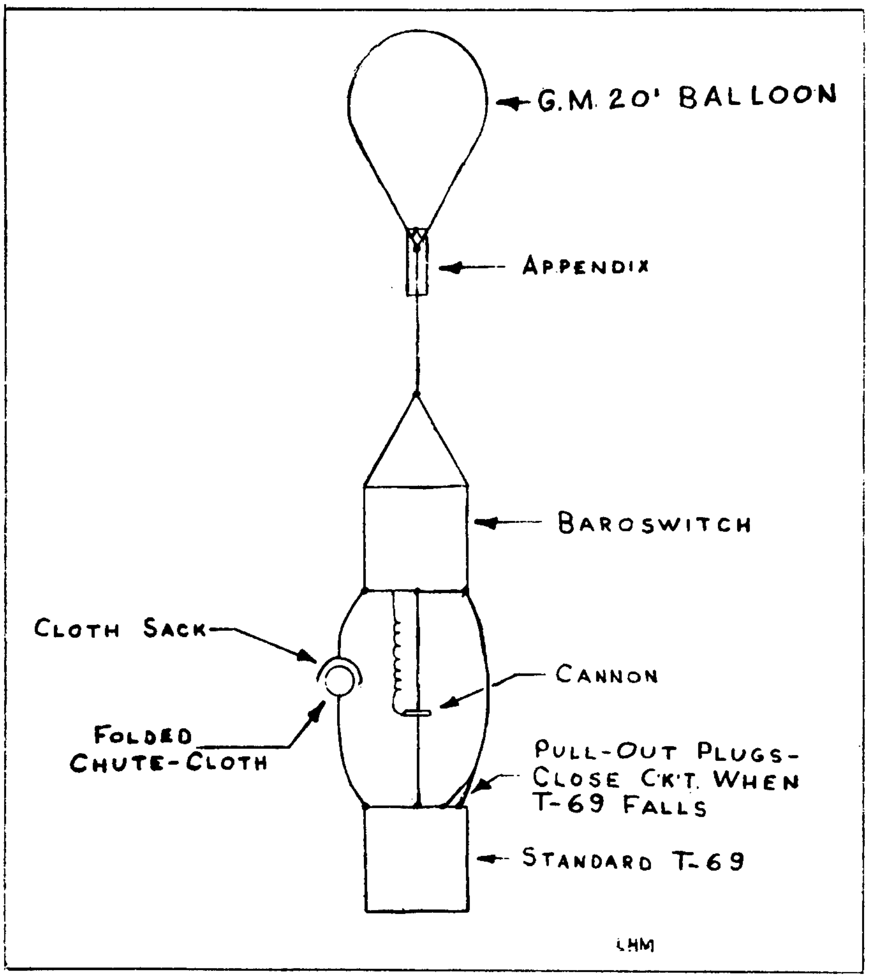


Figure 36: Equipment train, Flight 85

open until the baroswitch fired the "cannon" which severed the supporting line. Then the circuit plugs were to be pulled from their stops, and the parachute was to be pulled from its sock, supporting the radiosonde on its descent.

The failure of this system to act may be attributed to the use of a squib to fire the line-cutter cannon. Subsequent tests at lower levels (where the squibs work better) were made with a satisfactory release and activation of the "dropsonde."

Flight 86: Released from Alamogordo, New Mexico, 0941 MST, August 19, 1948
Recovered at Valmont, New Mexico

This was the fourth flight made with a single, 7-foot, .001" polyethylene balloon (Figure 37), carrying a light load to relatively low altitudes.

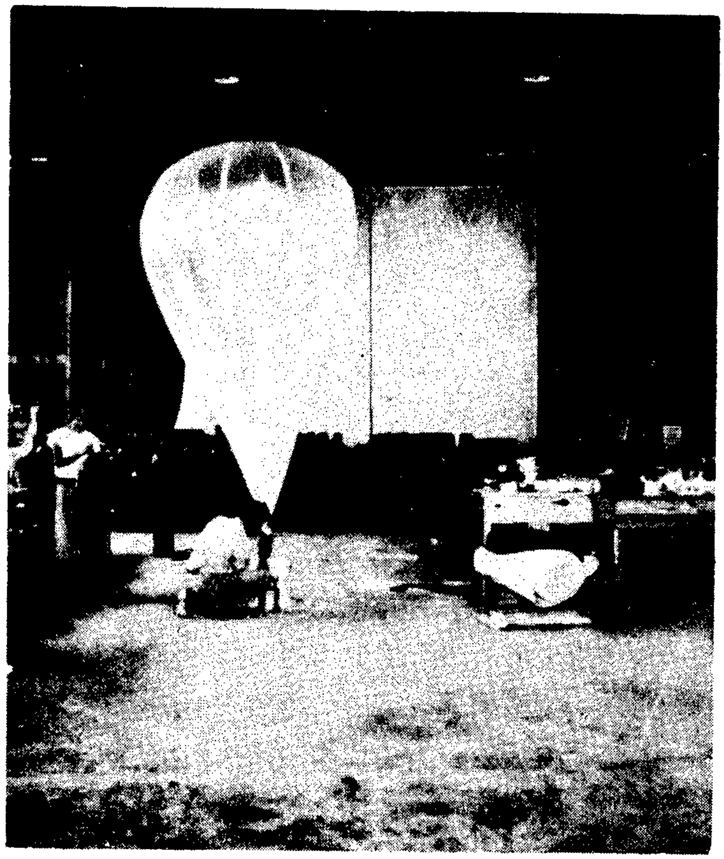


Figure 37: 7-Foot polyethylene balloon

On Flight 74, the automatic ballast meter showed that a ballast flow of 200 grams per hour was required by an automatic ballast valve on such a balloon. Flight 84 was launched in August, 1948 with a low-altitude barograph and no altitude controls to ascertain how long such a balloon would stay up. Using radar and helicopter that balloon was tracked for nearly 2 hours at an altitude of 12,500 feet with a load of 3 kilograms. It was still floating when lost.

On Flight 86, a fixed ballast leak was used, set at 170 grams per hour. After an early failure of the radiosonde transmitter, this balloon was followed with a plane; a floating level of about 14,500 feet was maintained for 4 hours, with a rise of "ceiling" of about 1200 feet per hour.

This balloon was observed during descent and was still distended, indicating that the lifting gas had been replaced by air both before and during descent.

Flight 88: Released from Alamogordo, New Mexico, 1241 MST, August 25, 1948
Recovered at Lovington, Texas

This flight was planned to measure the diffusion and leakage of lifting gas through a 20-foot, .001" polyethylene balloon at 40,000 feet. A fixed-leak orifice was set to flow at 100 grams per hour, and an automatic ballast valve was included to supply more ballast as demanded. This automatic valve broke on release, and the flow of 100 grams per hour was not sufficient to keep the balloon and equipment up.

Temperature data on this flight was obtained from thermistors inside the balloon, inside the battery and in the free air. These data and the height-time curve are shown in Figure 38. During the period from 1400 to 1530 when

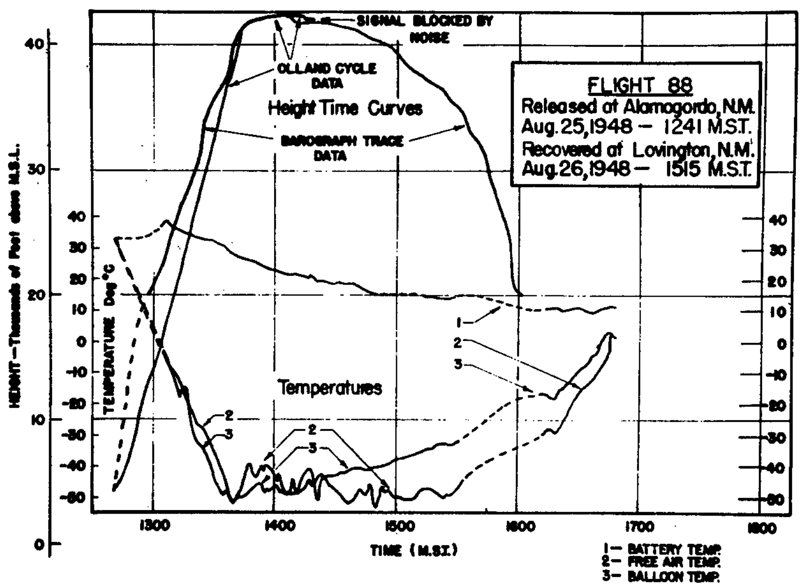


Figure 38

the balloon was slowly descending, the temperature of the gas increased with respect to the free air temperature, and a differential of 15°C was recorded at 1530. With subsequent, more rapid descent, this differential was reduced, presumably by ventilation. The battery box temperature remained above 10°C after four hours aloft.

Flight 89: Released from Alamogordo, New Mexico, 1005 MST, August 26, 1948
Not recovered

On this flight a .001", 20-foot polyethylene balloon was used to carry a ballast meter to about 45,000 feet to determine the ballast requirements at that altitude, using an automatic ballast valve. No record of ballast flow was telemetered during this flight, but it is not known whether the ballast meter was inoperative or the ballast valve itself failed--possibly due to failure of a squib to detonate at the combined low pressure and cold temperatures aloft.

From the height-time curve, Figure 39, it will be noted that the balloon was in a near floating condition for about five hours after reaching its maximum altitude. The total weight available on this flight was 2 kg, so a loss of 400 grams per hour would have been required if the ballast was used during this period.

From Flights 70 and 71 we know that a balloon has remained for about four hours at slightly higher altitudes with no ballast flow to support it; Flight 89, therefore, is not necessarily an example of the action of the automatic ballast valve control.

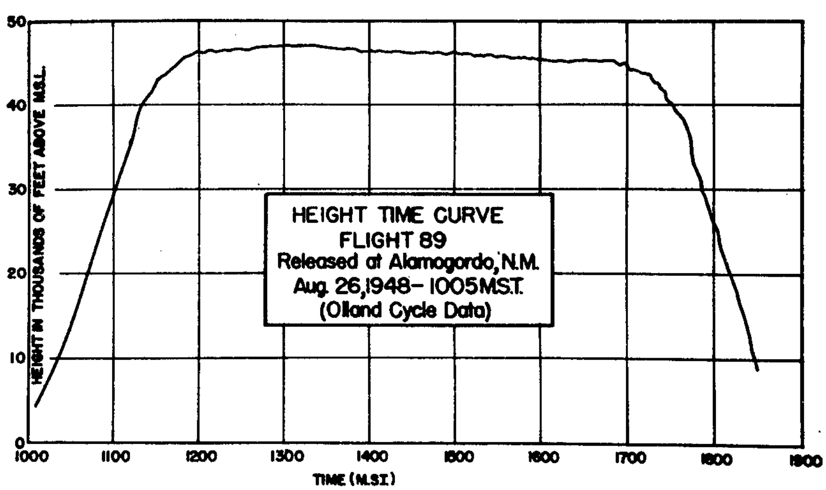


Figure 39

Flight 90: Released from Alamogordo, New Mexico, 1502 MST, August 27, 1948
Recovered at Roswell, New Mexico

The .001", 20-foot polyethylene balloon used on this flight was released in mid-afternoon to provide a test of the sunset effect on a balloon supported by the automatic ballast valve.

From the height-time curve, Figure 40, it may be seen that the balloon had attained a floating altitude shortly before the sunset and that the action of the automatic ballast valve was sufficient to restore the buoyancy

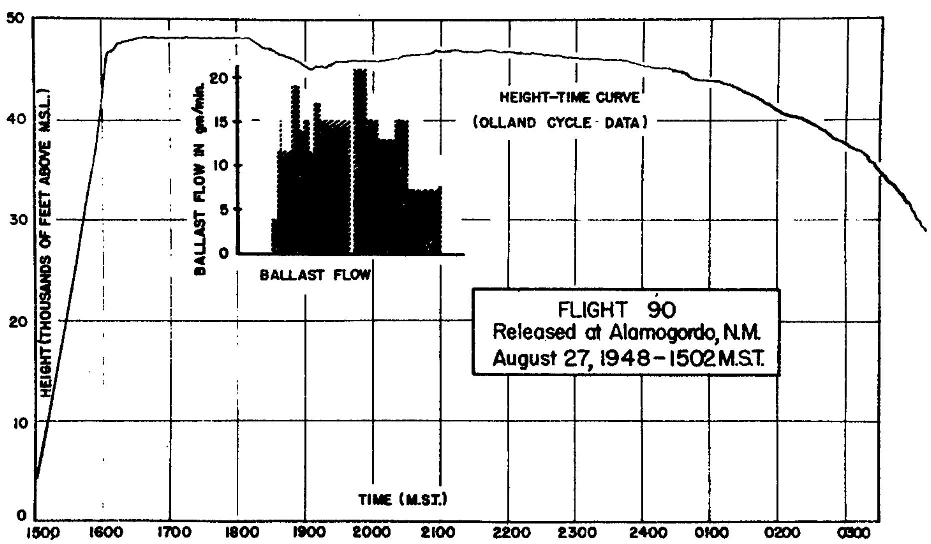


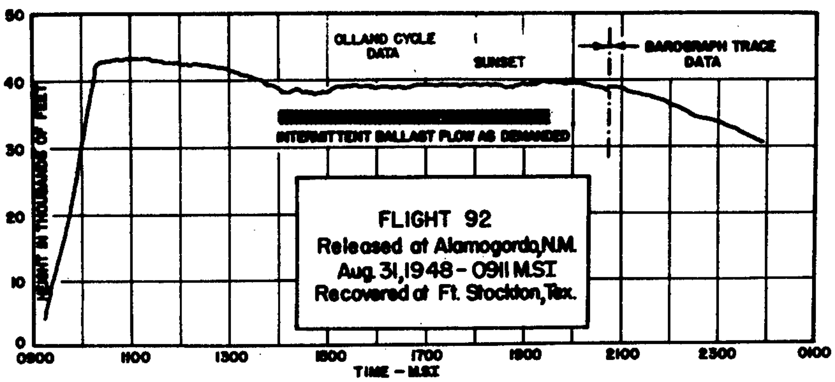
Figure 40

and cause the balloon to again reach a floating condition. The difference between the two floating levels may be explained by a consideration of the automatic ballast valve and the minimum-pressure switch which was used to seal off its aneroid capsule. Since the balloon had not fallen far enough to permit the switch to seal off the valve before sunset, this action was accomplished during the sunset descent (caused when the superheated helium lost the sun's heating effect). A further descent of 5 mb (500 feet at this level) was required to start the flow of ballast. By this time, the balloon had lost considerable lift and in exchange had acquired a downward velocity of about 120 feet per minute. To check this descent a ballast flow was required for about 40 minutes. During the next hour the balloon was buoyant and climbing back to the seal-off pressure of the automatic ballast valve. The inefficiency of this valve system is demonstrated by the ballast which was lost after the balloon had regained its buoyancy and had begun to rise. More ballast was wasted than was required to check the descent. Indeed, the entire 3000 grams available was expended at this time, according to the evidence of the ballast meter.

On this flight there was no apparent change in the activation pressure of the automatic ballast aneroid between the times when ballast flow began and ended. This indicates that the entrapped air had not experienced any significant temperature change during the two hours of ballast operation.

Flight 92: Released from Alamogordo, New Mexico, 0911 MST, August 31, 1948
Recovered at Ft. Stockton, Texas

On this flight an automatic ballast valve (with ballast meter) was used to support a 20-foot, .001" polyethylene balloon. The automatic ballast valve operated properly for about six hours, and 3000 grams of ballast was exhausted soon after sunset. In this case (Figure 41) the floating level of the



G.M. 20' Balloon with Automatic Ballast Valve

Figure 41

balloon was not seriously affected by sunset as was the case in Flight 90, since the balloon had already descended to the activation level of the automatic ballast valve. This descent followed about three hours of relatively stable flight during which time no ballast was released. The 5000-foot descent represents the delay in operation caused by the activation of the aneroid capsule by a minimum-pressure switch, added to the lag of the aneroid itself. Following the initial activation at about 38,500 feet, small oscillations were introduced into the flight pattern by the action of the automatic ballast valve.

Flight 92 provides a good example of the control of a balloon's altitude by the use of a pressure-set automatic ballast valve. In such a flight there is no tendency to rise to higher and higher levels. The adulteration of the lifting gas with air reduces the buoyancy of the balloon, and through the ballast-valve control, the load is diminished to the same extent so that equilibrium is maintained at the activation pressure of the automatic ballast valve's aneroid. In this flight the altitude constancy achieved was the best of all flights made to date. For seven hours and 35 minutes this balloon was held within 1000 feet at 38,000 feet MSL. (At this altitude 1000 feet corresponds to a pressure difference of 10 millibars.)

The sunset effect resulted in a rise of about 500 feet (5 mb) in the floating level of the balloon at 1830 MST. This seems to be due to a change in the effective seal-off pressure of the aneroid capsule of the automatic ballast valve which was the consequence of a decrease in the temperature of the trapped air inside. The rise in altitude experienced corresponds to a decrease of temperature of about 6°C, the superheat of the aneroid, which was lost at sunset. This valve may be compared with the 30°C found on Flight 10. On the earlier flight a black valve was used while on this flight the equipment was polished aluminum, with a highly reflective surface.

Flight 93: Released from Alamogordo, New Mexico, 0712 MST, September 1, 1948
Recovered at Neuvas Casas Grandes, Chihuahua, Mexico

This daytime flight with a 20-foot, .001" polyethylene balloon went up with defective ballast controls; consequently the flight's main value is in showing the natural stability of such a balloon without any altitude controls. As with Flight 88, which went to about the same height (40,000 feet), this balloon remained at a near-floating level for less than two hours (Figure 42). It is interesting to compare this duration at 40,000 feet with the four-hour duration at 50,000 feet shown on Flight 70 and 71. Probably the effect of reduced pressure on diffusion of the lifting gas is a major factor contributing to the longer floating period at the lower pressure.

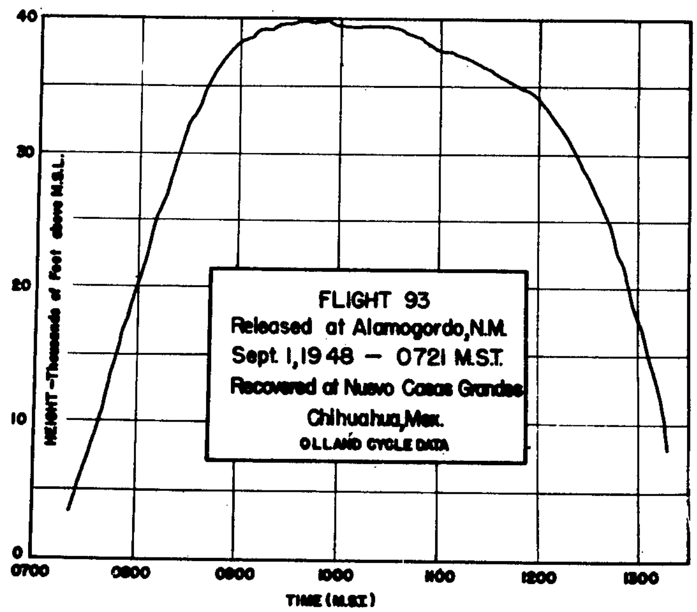


Figure 42

Flight 94: Released from Alamogordo, New Mexico, 1208 MST, September 3, 1948
Recovered At Villa Ahumada, Chihuahua, Mexico

On this flight, a fourth attempt was made to sustain a Seyfang, neoprene-coated nylon balloon. On Flight 79, a previous Seyfang flight, no ballast equipment had been in operation, and so a careful record of ballast flow on Flight 94 was desired. This was provided by a ballast meter. In addition to this and the barograph and Olland pressure-measuring instruments, a thermograph was also part of the equipment train.

The height-time curve (Figure 43) shows that the initial buoyancy surplus of this balloon (for the most part due to superpressure held behind

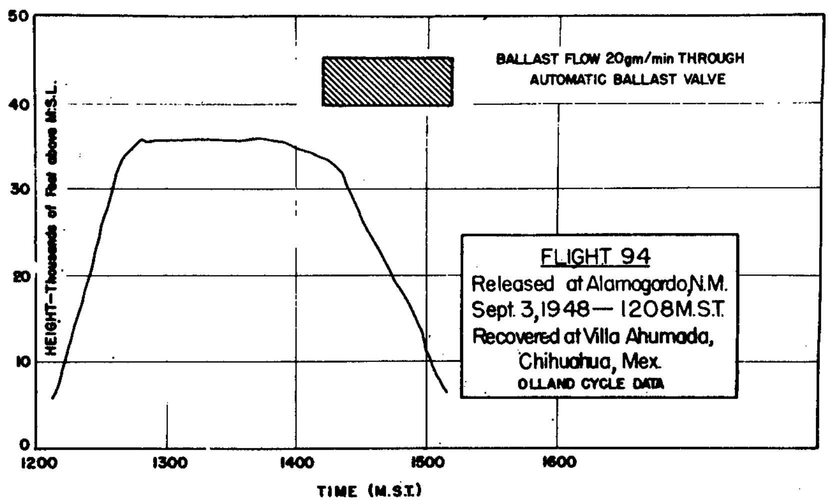


Figure 43

the safety valve) was reduced by diffusion so that after one hour of floating it began to descend at an accelerating rate. After falling about 2000 feet, the automatic ballast valve began to operate, and ballast was discharged at the rate of 20 grams per minute. During the descent, however, the strong superheat which the balloon had acquired was reduced by ventilation.

The adiabatic lapse rate of helium is 2°C per kilometer, whereas air in the troposphere warms up about 6°C with each kilometer of descent. This means that with each kilometer of fall, the lifting gas was cooled relative to the air by an additional 4°C. The combination of inertia, loss of superheat through ventilation, and adiabatic cooling of the gas as it was compressed, proved too great for the limited flow of ballast through the automatic valve, and the balloon fell unchecked to the ground.

From Flight 79, it was determined that superheat of nearly 40°C is built up when Seyfang balloons are flown in the sunshine. If this were lost, the buoyancy of the balloon would be reduced by one-sixth, and no satisfactory control could be achieved by ballast dropping.

Flight 96: Released from Alamogordo, New Mexico, 0733 MST, September 8, 1948
Not recovered

On Flight 96 a .001", 20-foot polyethylene balloon was used to carry a ballast meter to about 45,000 feet to determine the flow required at that altitude using an automatic ballast valve. No record of ballast flow was telemetered during this flight, but it is not known whether the meter was inoperative, or the valve itself failed--possibly due to failure of a squib to detonate at the combined low pressure and cold temperature aloft.

From the height-time curve, Figure 44, it will be noted that the balloon was in a near-floating condition for about four hours when the transmitter

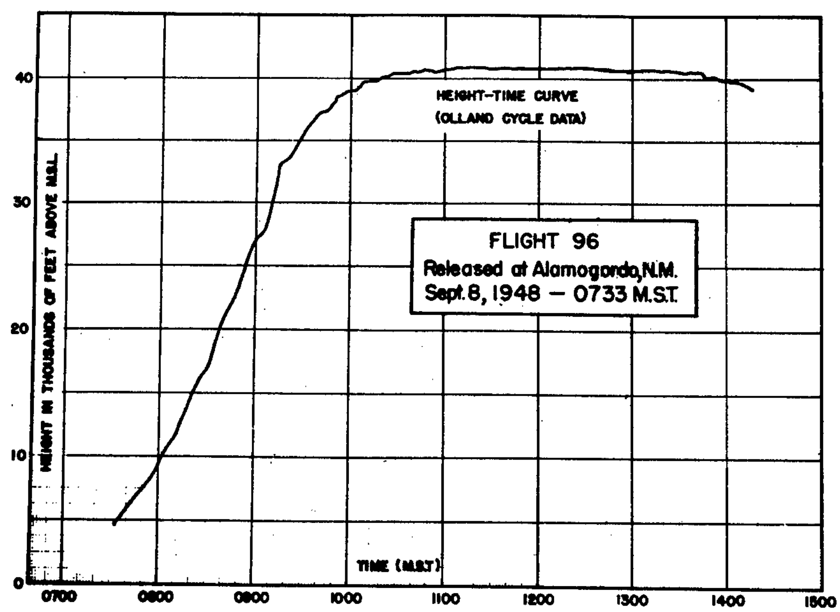


Figure 44

signal gave out. There is no way of telling whether the constant-level flight obtained was due to the natural buoyancy of the balloon or the action of the automatic ballast valve.

Flight 97: Released from Alamogordo, New Mexico, 0856 MST, September 10, 1948
Recovered at Duncan, Oklahoma

On this flight a .001", 20-foot polyethylene balloon was used to test a new type of ballast control. In this system, ballast flow was excited at any altitude if the balloon descended at a rate equal to or greater than 1 millibar in five minutes.

The buoyancy record and the Olland-cycle pressure data obtained from this flight show a disagreement of about 10,000 feet (Figure 45). No explanation has been provided for this difference and the following evidence has been considered. The predicted floating level was about 45,000 feet, in agreement with the Olland-cycle radiosonde data. On the other hand, the balloon rose extremely slowly and may have taken in air to dilute the lifting gas. In this event, the floating level might easily have been reduced by 10,000 feet.

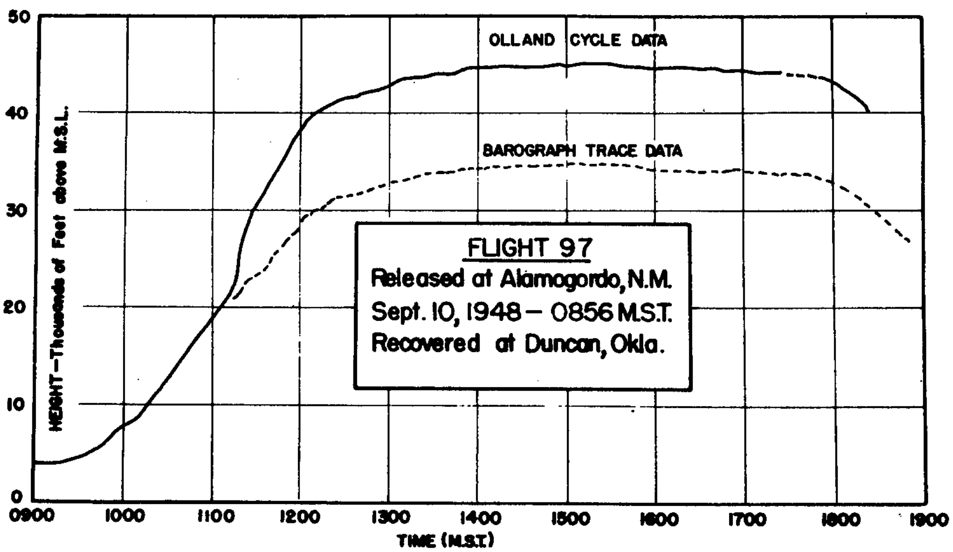


Figure 45

Once at the floating level, however, the balloon was maintained within 1000 feet (or 1200 feet) of a constant level for over four hours. This indicated that the control system was in operation since previous flights (88 and 93) at this altitude descended after about two hours of flight without ballast.

Flight 98: Released from Red Bank, New Jersey, 0948 EST, October 28, 1948
Not recovered

On Flight 98 a 20-foot, .001" polyethylene balloon was used to test radio reception using a new model of the Olland-cycle modulator and a T-69 radiosonde transmitter. Three receiving stations were used, with elevation and azimuth angles as well as the pressure altitude recorded by RDF (SCR-658) equipment. The trajectory of this flight (Figure 46), reconstructed from the data received at the ground station, indicates that the balloon was more than

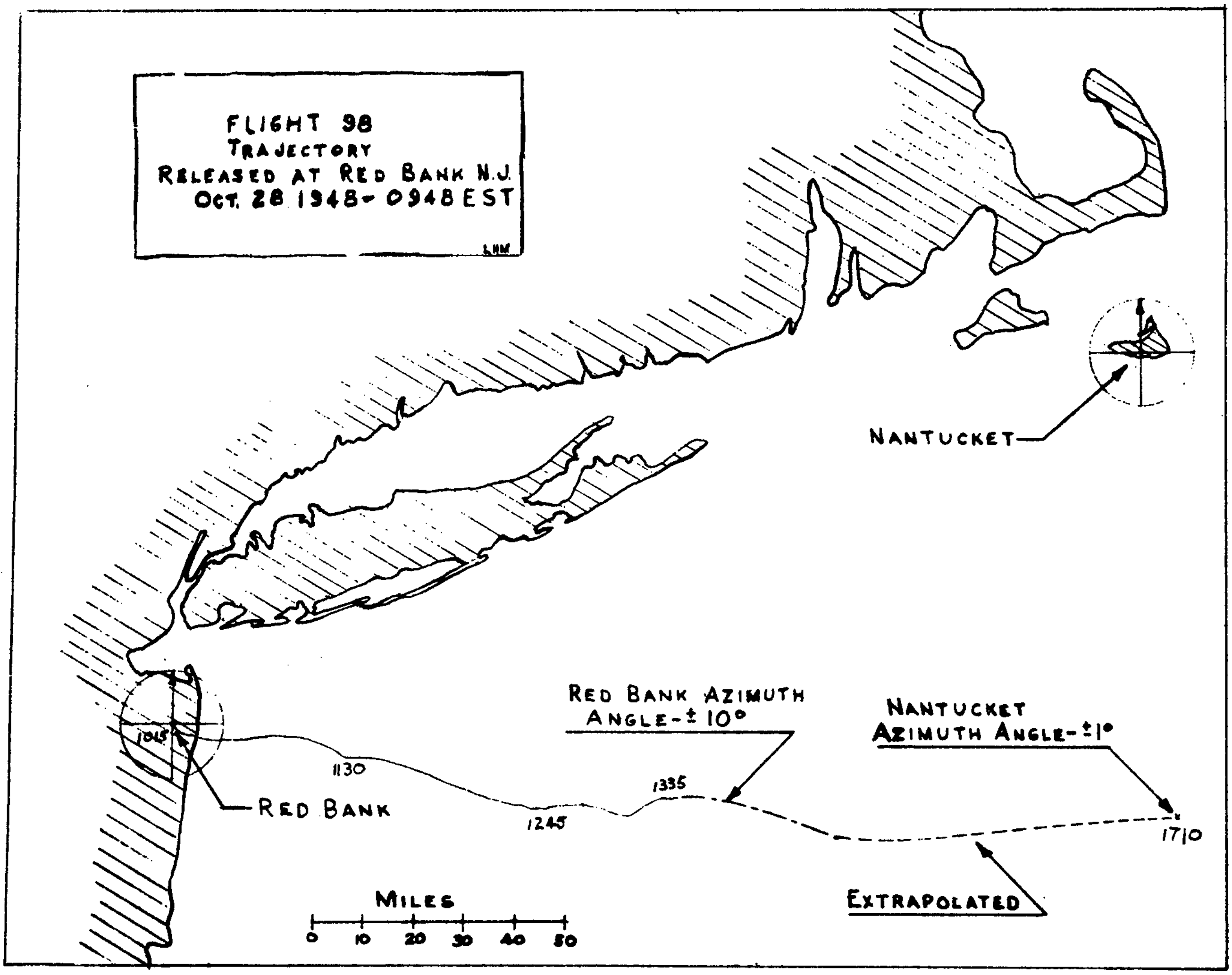


Figure 46

175 miles from the Nantucket station at the time the signal was first received. This reception is much greater than may be expected from most

SCR-658 ground sets when the T-69 transmitter is used. The signals obtained were not very strong, and there was only an interrupted record of the pressure height. From the height-time curve (Figure 47) it will be seen that a three- to four-hour period of floating was recorded, at an altitude near 50,000 feet MSL. This is in good agreement with the results obtained from earlier flights (70 and 71) at this level when no control apparatus was included.

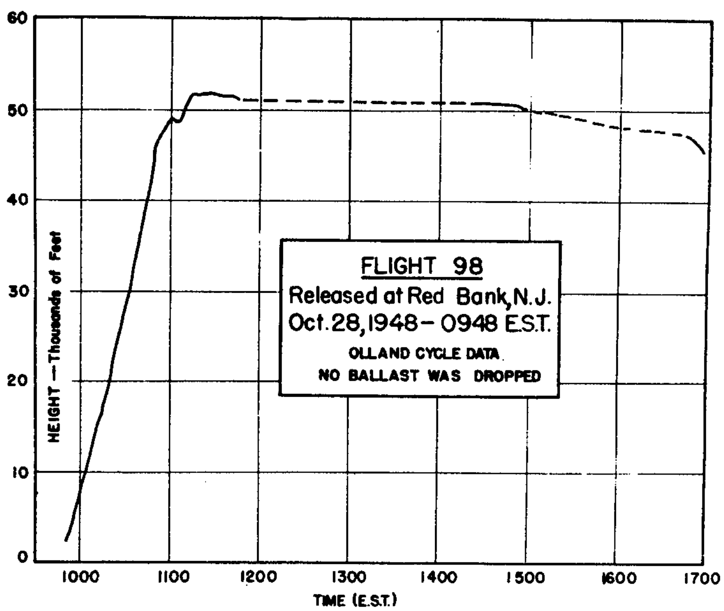


Figure 47

Flight 102: Released from Red Bank, New Jersey, 1023 EST, December 9, 1948
Not recovered

Flight 102 was the first test given to a 30-foot, .001" polyethylene balloon manufactured by General Mills, Inc.; with this balloon a 30-kilogram payload was successfully lifted to 58,000 feet. A combination rate-of-ascent switch and displacement switch was used to control ballast flow, but no record of ballast was made since the ballast meter was broken at launching.

Flight data was received by three ground stations, and the signal from the AM-1 transmitter (with about 10 pounds of batteries) was received for about 400 miles. This was a good test of the distance to which a signal may be transmitted by the AM-1 (N.Y.U) transmitter under daytime conditions. The trajectory of this flight is Figure 48.

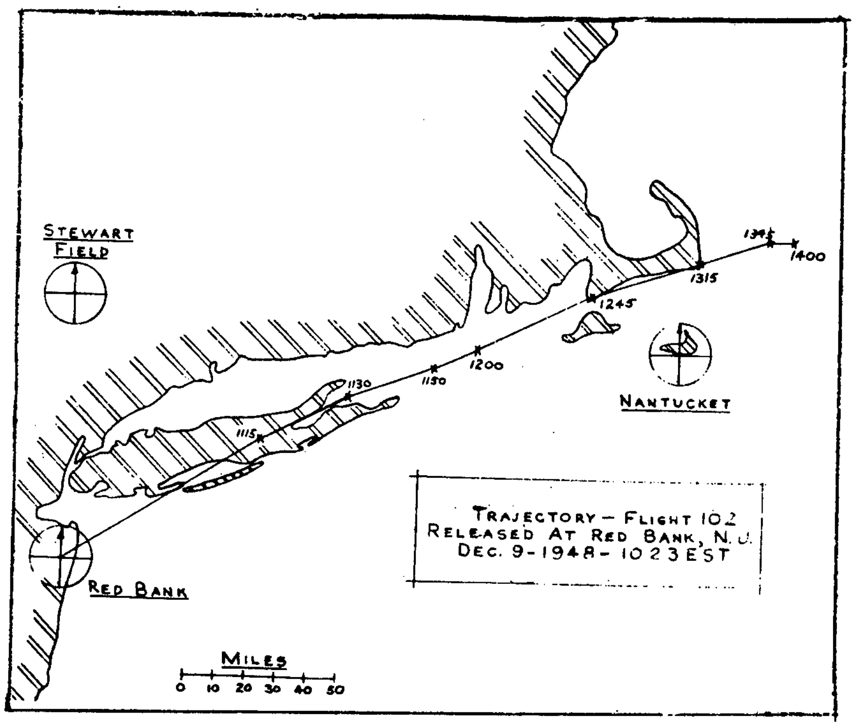


Figure 48

In the height-time curve (Figure 49) it is interesting to note the descent which began shortly before sunset. There is reason to believe that this fall was being checked by ballast flow. The normal descent after a balloon begins to fall is accelerating, while on this flight acceleration is evident. With a loss of 10°C superheat, and a limited flow (900 grams per hours), it would require two hours of flow to restore the buoyancy of the balloon. This is a demonstration that more rapid compensation is required.

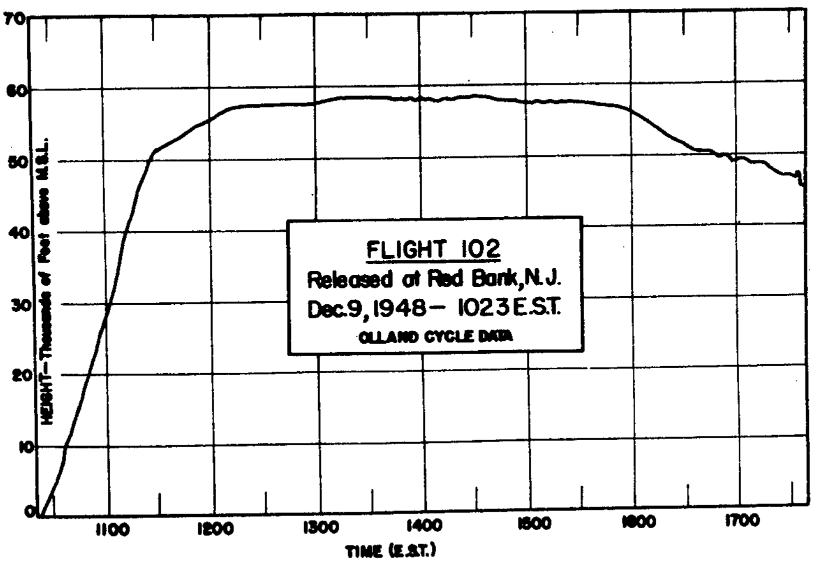


Figure 49

Flight 103 through 111: These flights were released in January and February, 1949 from Alamogordo, New Mexico to test the action of the combined ballast controls (displacement switch and rate-of-ascent switch). Receiving units were stationed at Alamogordo; at Miami, Oklahoma and at Nashville, Tennessee; aircraft were used both to receive the signal and also to track and position the balloon by the use of the radio compass.

For the first time on these flights, a program switch was used to permit a single transmitter to transmit three temperature signals as well as ballast-flow data and pressure information. By interrupting the pressure and ballast data for short intervals of temperature data, all of this information was telemetered with the AM-1 (N.Y.U.) transmitter.

Aircraft reception of 500 miles was reported on these flights, but ground reception was limited to about 250 miles, perhaps due to mountains surrounding the receiving station.

No significant data was obtained on four of these flights, and on two more the principal objective of the flight was defeated by the excessive gas loss from the balloons.

From the height-time curves of Flights 103 and 107 (Figures 50 and 51) may be seen that even with constant ballast flow (at 2400 grams per hour)

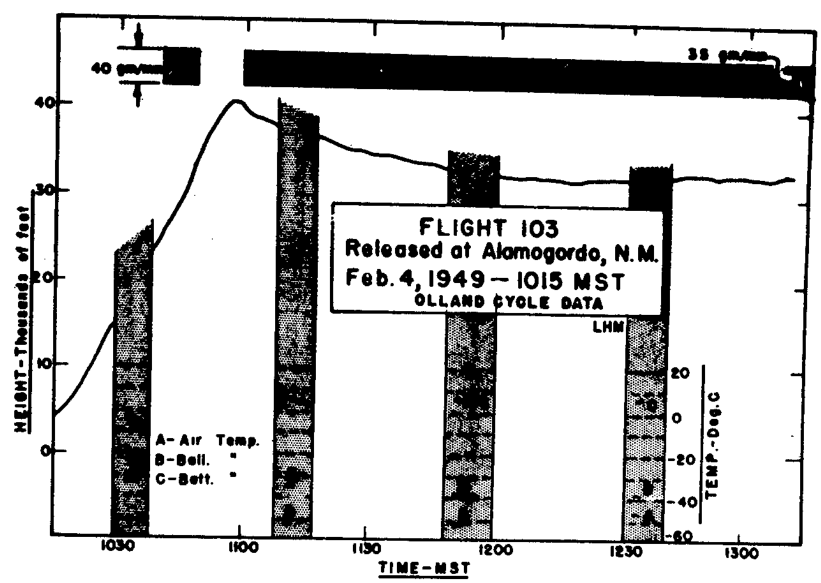


Figure 50

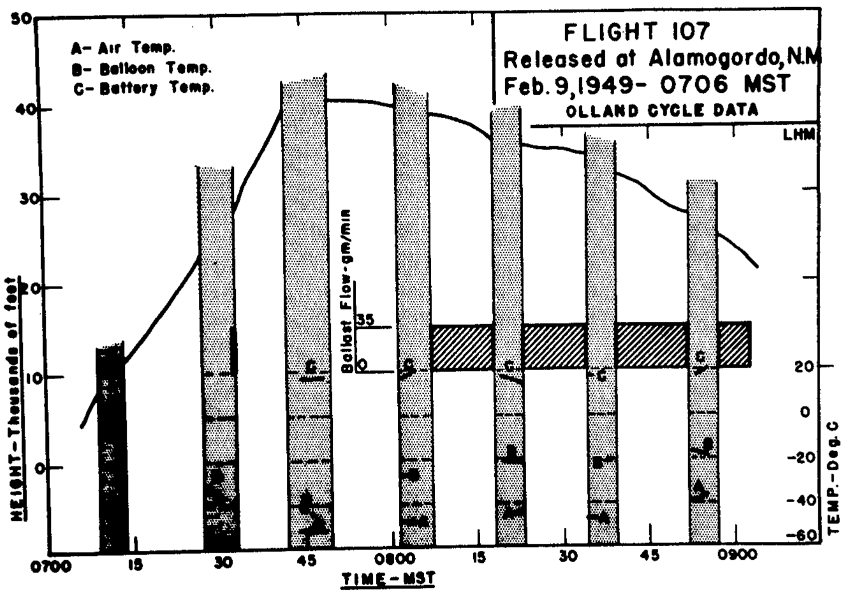


Figure 51

the balloon continued to descend. In both cases the token ballast flow on the ascent portion of the flight indicates that the controls were operative, but there was no test of efficiency since on-off operation was never permitted.

The temperature data of these flights is in generally good agreement with that seen earlier with the balloon gas being warmed by the sun to acquire a superheat of 10° to 20°C.

Flight 103: Released from Alamogordo, New Mexico, 1015 MST, February 4, 1949
Recovered at Mountain View, Oklahoma

On Flight 103 a B-17 airplane was used to follow the balloon, homing in on the signal from the AM-1 transmitter with the radio compass. There were few clouds over the first section of the balloon's path, and very exact positioning was obtainable. The compass needle reversed almost immediately, and no cone of silence was found when the plane passed beneath the balloon. The fixes indicated on the trajectory (Figure 52) show how exactly the path of the balloon may be determined when tracked in such a manner.

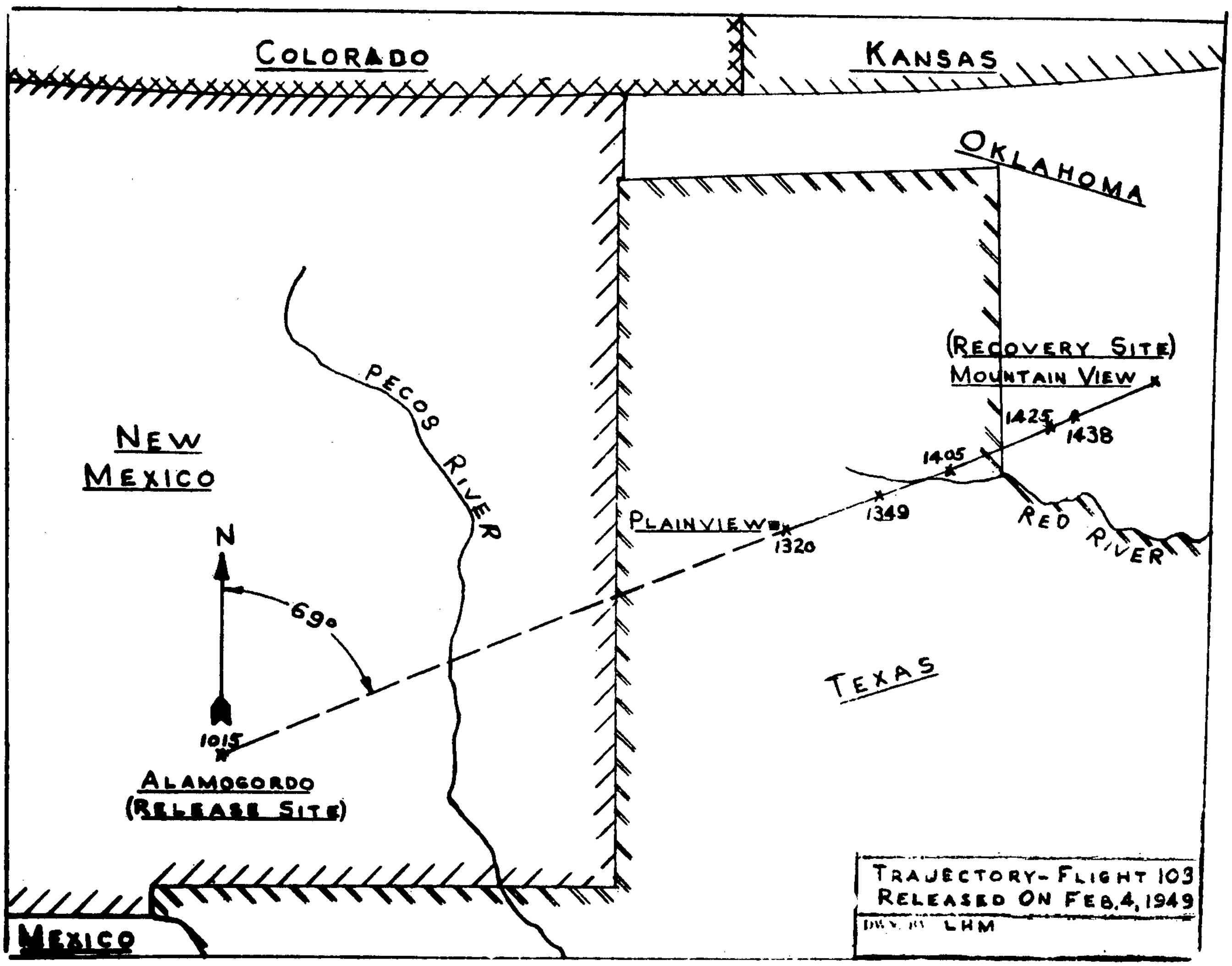


Figure 52

Flight 104: Released from Alamogordo, New Mexico, 1123 MST, Feburary 5, 1949
Recovered at Hale Center, Texas

On this flight a stepwise floating level was achieved by the dropping of weight from the 20-foot, .001" polyethylene balloon. From the height-time curve (Figure 53) the climb from 35,000 feet MSL to 47,000 MSL can be seen. A time clock was used to start the rapid flow of ballast after about one hour at the first level. Following the exhaustion of all ballast, the ballast reservoir itself was released to cause the final rise of the balloon.

By the use of this technique, atmospheric sampling of any kind may be conducted with two or more levels sampled on a single flight. Without using any control to keep the balloon constantly at a given altitude for a long time, the sampling steps should not be expected to be much longer than one hour apiece.

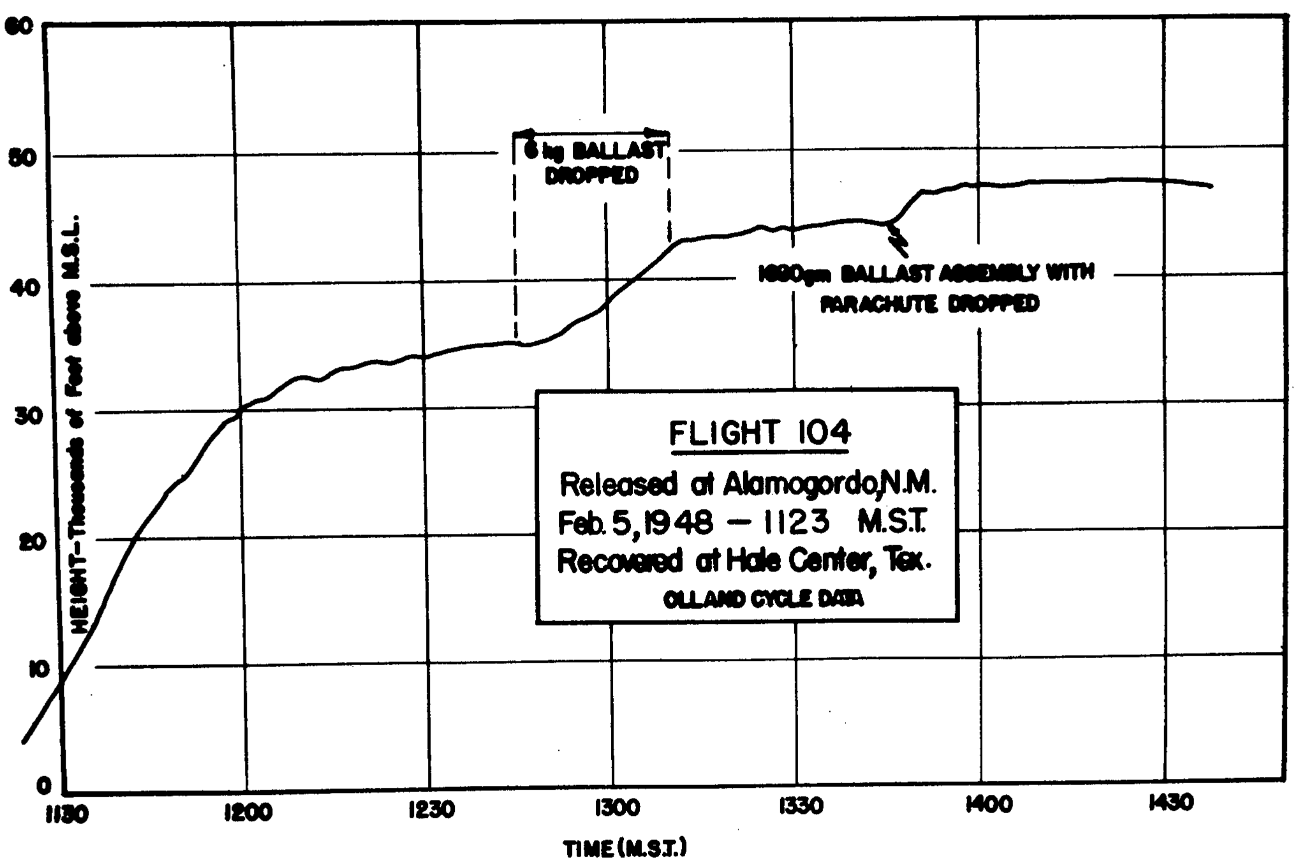


Figure 53

Flight 106: Released from Alamogordo, New Mexico, 0657 MST, February 8, 1949
Recovered at Ellsmore, Kansas

This was the first flight to clearly demonstrate the efficient action of a combination ballast control--displacement switch and rate-of-ascent switch--on a 20-foot, .001" polyethylene balloon. From the height-time curve and ballast-flow record (Figure 54), it will be seen that the ballast control was operating at 41,000 feet MSL during the period of radio reception from Alamogordo, New Mexico. By the time the second receiving station picked up the signal, all of the ballast had been exhausted and the balloon was falling. On this flight a high loss of lifting gas caused the total ballast load of 600 grams to be exhausted in less than five hours. (Average used in first two hours was 1700 grams per hour.)

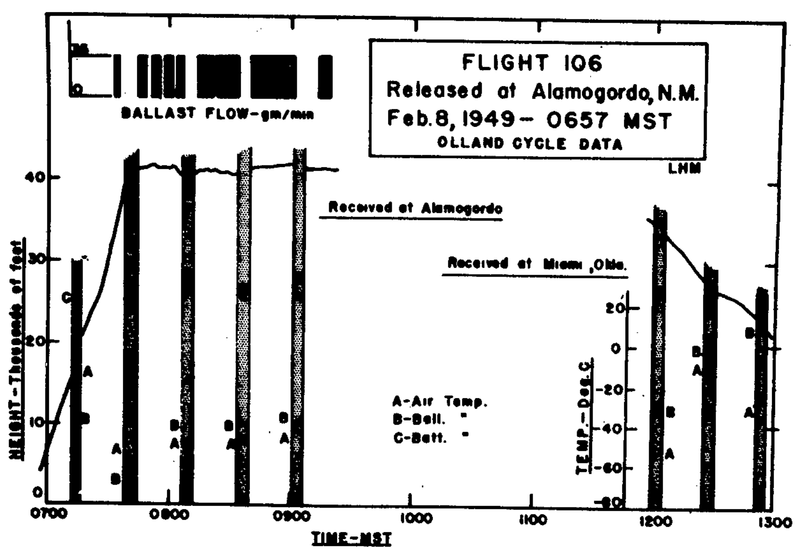


Figure 54

The descent point of this balloon was compared with that predicted from a study of the atmospheric pressure patterns at floating level. Assuming geostrophic flow, members of a graduate class in meteorology at New York

University computed the points of descent seen in Figure 55. As in the cases of Flights 55 and 58, the balloon appears to have moved across the isobars toward lower pressure.

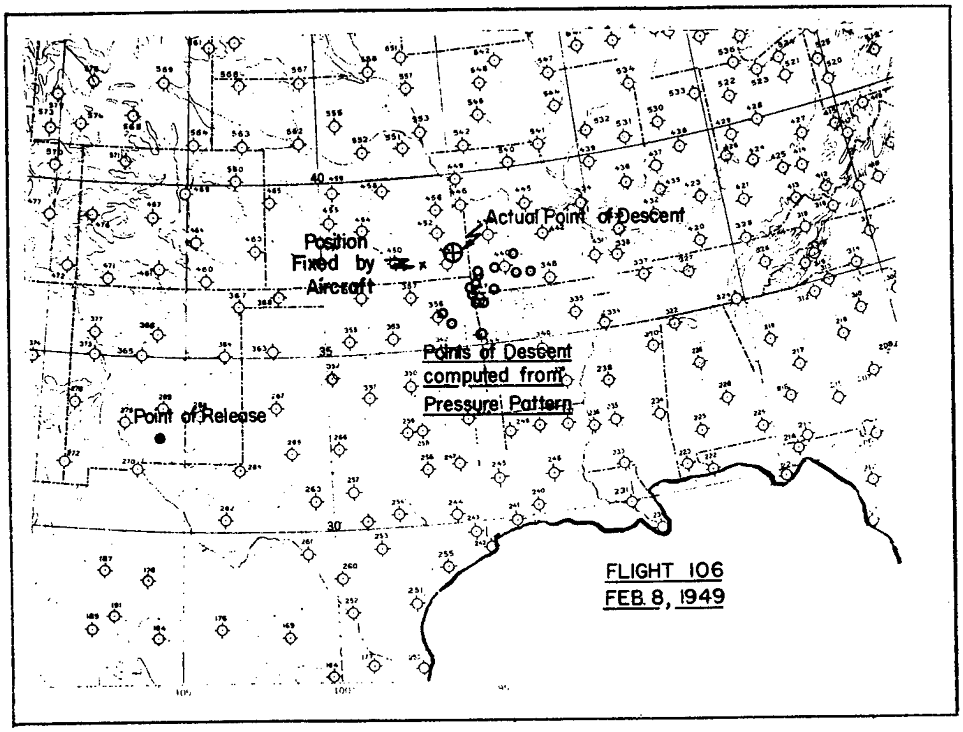


Figure 55

Flight 110: Released from Alamogordo, New Mexico, 0649 MST, February 11, 1949
Recovered at Kershaw, South Carolina

This flight had as its main objectives the testing of a Winzen Research Inc. .0015", 20-foot polyethylene balloon, and further testing of the combination ballast control--displacement switch and rate-of-ascent switch. Following the initial ascent of this flight, a slow descent resulted from loss of lifting gas. Three hours were required for a descent of 2000 feet to the pressure where ballast flow was begun. This and the general flight pattern indicate the satisfactory nature of this Winzen Research Inc. balloon. After ballast started, the valve stuck and a constant flow at 1800 grams per hour followed. The rising ceiling seen in Figure 56 is the typical flight pattern for a balloon whose load is being steadily decreased at a rate in excess of the loss of buoyancy.

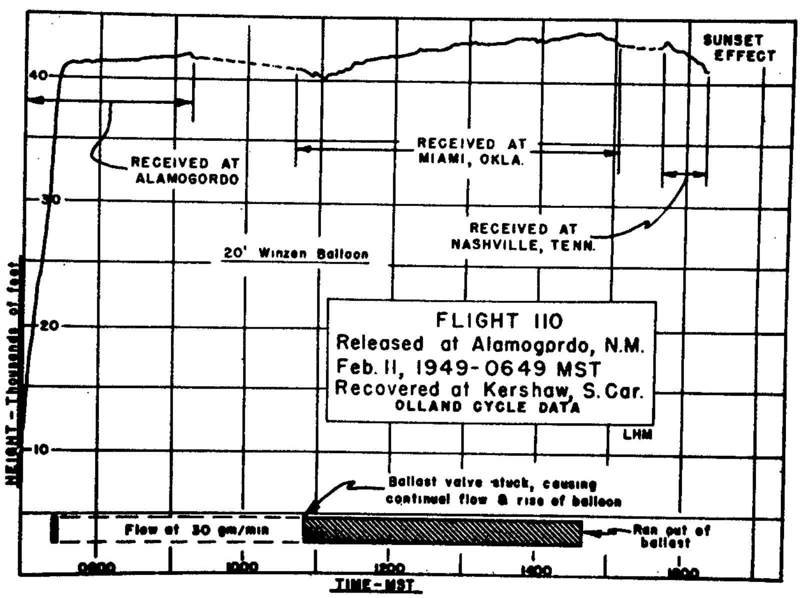


Figure 56

On this flight all three of the receiving stations positioned along the expected path were able to receive and record the pressure and ballast signal. No temperature equipment was flown.

A comparison of the point of descent predicted from geostrophic flow and that actually observed was made by members of a graduate class of meteorology at New York University (Figure 57). Using an airplane fix

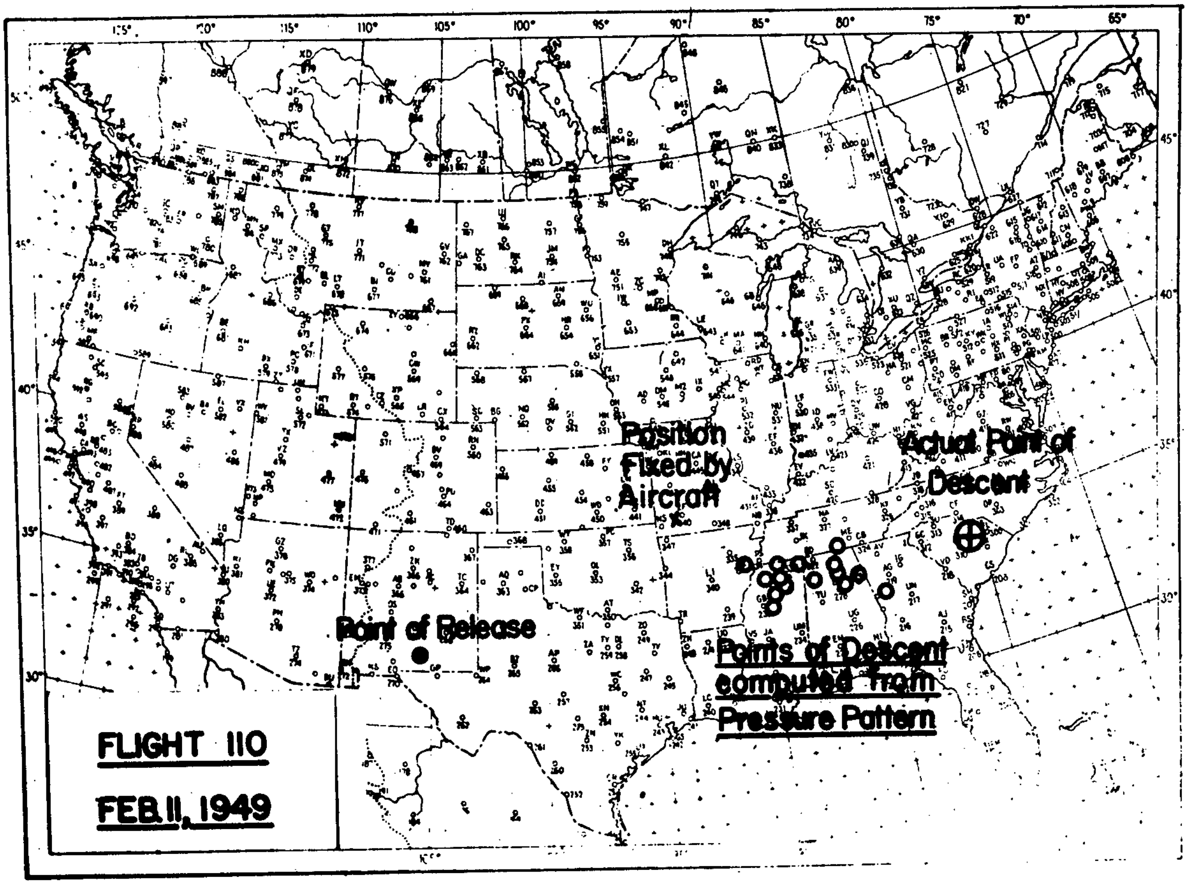


Figure 57

made during the flight the actual trajectory seems to have been well to the north of the "center of gravity" of predicted points of descent, and the actual flight path was considerably longer than that predicted. Since the pressure pattern at the eastern end of the flight was anticyclonic, this seems to be in accordance with the idea of super-geostrophic flow associated with anticyclonic systems. As in all the earlier cases where such a study was made, the balloon apparently moved across the isobars toward lower pressure.

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